Current and Sea-Level Measurements in the Northwest Passage
Volume 1, March 1982 - April 1983.

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Canadian Data Report Of Hydrography and Ocean Sciences

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Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences,* Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

Rapport statistique canadien sur l'hydrographie et les sciences océaniques

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Les établissements des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports depuis décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques,* la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du Rapport n° 1 en janvier 1982.

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CURRENT AND SEA-LEVEL MEASUREMENTS IN THE NORTHWEST PASSAGE
VOLUME 1, MARCH 1982 - APRIL 1983.

by

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PREFACE

This report is the first of three data reports documenting current and sea-level measurements in the Northwest Passage of the Canadian Arctic Archipelago between March 1982 and April 1985. Each report deals with the activities undertaken during a year-long period. Analysis and interpretation of these data appear in a separate technical report.

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ABSTRACT

Buckingham, W.R., R.A. Lake, and H. Melling, 1987. Current and Sea-Level Measurements in the Northwest Passage. Vol. 1, March 1982 - April 1983. Can. Data Rep. Hydrogr. Ocean Sci. No. 51:128 pp.

A three-year program of current and sea-level measurements was undertaken between March 1982 and April 1985 in the Canadian Arctic Archipelago by the Institute of Ocean Sciences of the Department of Fisheries and Oceans. The measurements were in the form of time series, at fixed depths by self-recording instrument packages, of temperature, salinity, current speed, current direction and water pressure at the sea-floor. The activities during each year of the study were concentrated on a specific region of the Northwest Passage within the Archipelago. The emphasis in 1982 was on the western portion (M'Clure Strait, Prince of Wales Strait, and Viscount Melville Sound), in 1983 on the central portion (eastern Viscount Melville Sound and Barrow Strait), and in 1984 on the eastern portion (Barrow Strait and adjacent channels). This report discusses the aims of the project, the logistics of the 1982 field work, and summarizes the data acquired during that year in tabular and graphic form.

key words: Arctic Archipelago, Northwest Passage, temperature, salinity, current, tide.

RESUME

Buckingham, W.R., R.A. Lake, and H. Melling, 1987. Current and Sea-Level Measurements in the Northwest Passage, Vol. 1, March 1982 - April 1983. Can. Data Rep. Hydrogr. Ocean Sci. No. 51:128 pp.

De mars 1982 a avril 1985, l'Institut des Sciences de la Mer du MPO a réalisé un programme triennal de mesures du niveau de la mer et des courants dans l'archipel arctique canadien. Ces mesures ont été prises sous forme de séries chronologiques, à des profondeurs déterminées, par des groupes d'instruments automatisés, de la température, de la salinité, de la vitesse et direction de courant et de la pression de leau au fond de la mer. Les activités annuelles ont porté sur une région déterminée du passage du Nord-Ouest de l'archipel. En 1982, l'accent a été mis sur la partie ouest (détroit de M'Clure, détroit de Prince-de-Galles, et détroit du Vicomte-Melville), sur la partie centrale en 1983 (parti est du détroit du Vicomte-Melville et détroit de Barrow), et en 1984, sur la partie est (détroit de Barrow et chenaux adjacents). Le présent rapport porte sur les buts du projet, le soutien logistique du travail sur le terrain en 1982 et résume les données recueillies cette année-là, qui sont présentées sous forme de tableaux et de graphiques.

Mots-clés: archipel arctique, passage du Nord-Ouest, température, salinité, courant, marée.

ACKNOWLEDGEMENTS

The authors wish to thank various members of the Institute of Ocean Sciences whose diligent efforts helped to make this project a success. In particular we thank electronics technicians P. Johnston and A. Koppel, support technicians S. Moorhouse and J. McNeill, and J.W. Green from the computing section. Logistic support, and accommodation at Resolute Bay was provided by the Polar Continental Shelf Project of the Department of Energy, Mines and Resources. The Canadian Hydrographic Service allowed us to join their field camp at Johnson Point, and provided us with meals and radio communications. Meals, radio and accommodations were also made available at Rae Point by Panarctic Oils, Ltd. We sincerely thank all three organizations, and the particular individuals involved, for their cooperation and assistance.

The funding for this project was provided by the Marine Transportation Research and Development Programme.

1. INTRODUCTION

A three-year physical-oceanographic study was undertaken between 1982 and 1985 in the Canadian Arctic Archipelago, centering on the complex of waterways known as the Northwest Passage. The study was carried out by the Department of Fisheries and Oceans at the Institute of Ocean Sciences (IOS). It extended from Amundsen Gulf in the west, through Prince of Wales Strait, M'Clure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound to Baffin Bay in the east (see Figure 1). The study also included the various passageways and basins bordering the Northwest Passage. The overall objective included the following goals:

1) the identification of the magnitude and direction of tidal and non-tidal currents,
2) the description of tidal propagation,
3) the identification of sources and destinations of various water-masses,
4) the identification of the relative importance of physical forces which determine currents and water-mass distribution (e.g. tidal forces, baroclinic forces related to horizontally inhomogeneous distribution of water density and non-tidal barotropic forces related to oceanic and atmospheric circulation),
5) the identification of temporal and spatial variability in current and water-mass distribution. Periods of particular importance are tidal (semi-diurnal and diurnal), seasonal, and interannual. Also of potential importance are singular or non-periodic events such as storm surges,
6) the estimation, to an order of magnitude, of the volume of water transport into and out of the study area and the partition of that transport.

The activities during each year of the study concentrated on a specific region of the Northwest Passage. The emphasis in 1982 was on the western portion. The field operations were undertaken during the early spring months, at which time the solid ice-cover made a stable platform from which to work.

This report describes the acquisition of water-current and sea-level information in 1982/83 as time series of current, temperature, salinity and sea-floor water pressure, and presents the data in final processed form. The main study area comprised the eastern end of M'Clure Strait and the western and middle portions of Viscount Melville Sound. The relevant current-meter mooring locations are indicated by the square symbols in Figure 2, and tide gauge locations by circular symbols. Tide gauges operated by other agencies are shown as diamond symbols while weather stations are indicated by asterisks. Data reports covering the activities initiated during 1983 and 1984 may be found in Volumes 2 and 3 of this report series.

A related oceanographic investigation undertaken concurrently by the Institute of Ocean Sciences in the adjacent channel of Prince of Wales Strait was termed the Channel Flow Experiment. The time series from this study are included in this report. The mooring stations for the Channel Flow Experiment are denoted in Figure 2 by square symbols or by a series of triple parallel lines (indicating transects), all located within Prince of Wales Strait. Relevant ocean measurements were acquired concurrently by the Canadian Hydrographic Service in Prince of Wales Strait (CHS-Pacific: seafloor water pressures and currents) and in M'Clure Strait (CHS-Central: seafloor water pressures) and by the Bayfield Laboratory for Marine Science and Surveys in Barrow Strait

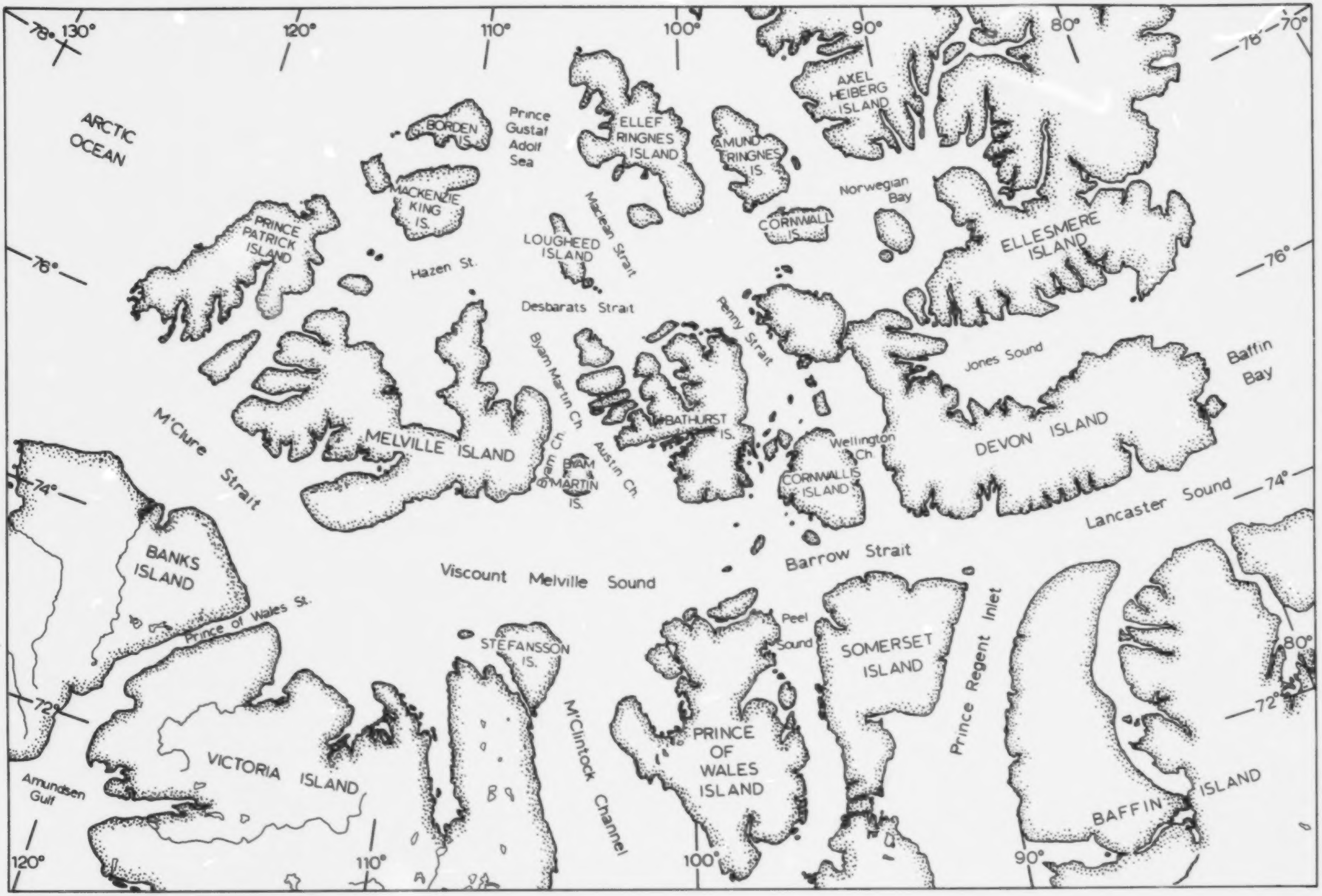

Figure 1. A map of the Canadian Arctic Archipelago. The Northwest Passage shipping route will likely be through Lancaster Sound, Barrow Strait, Viscount Melville Sound, and Prince of Wales Strait.

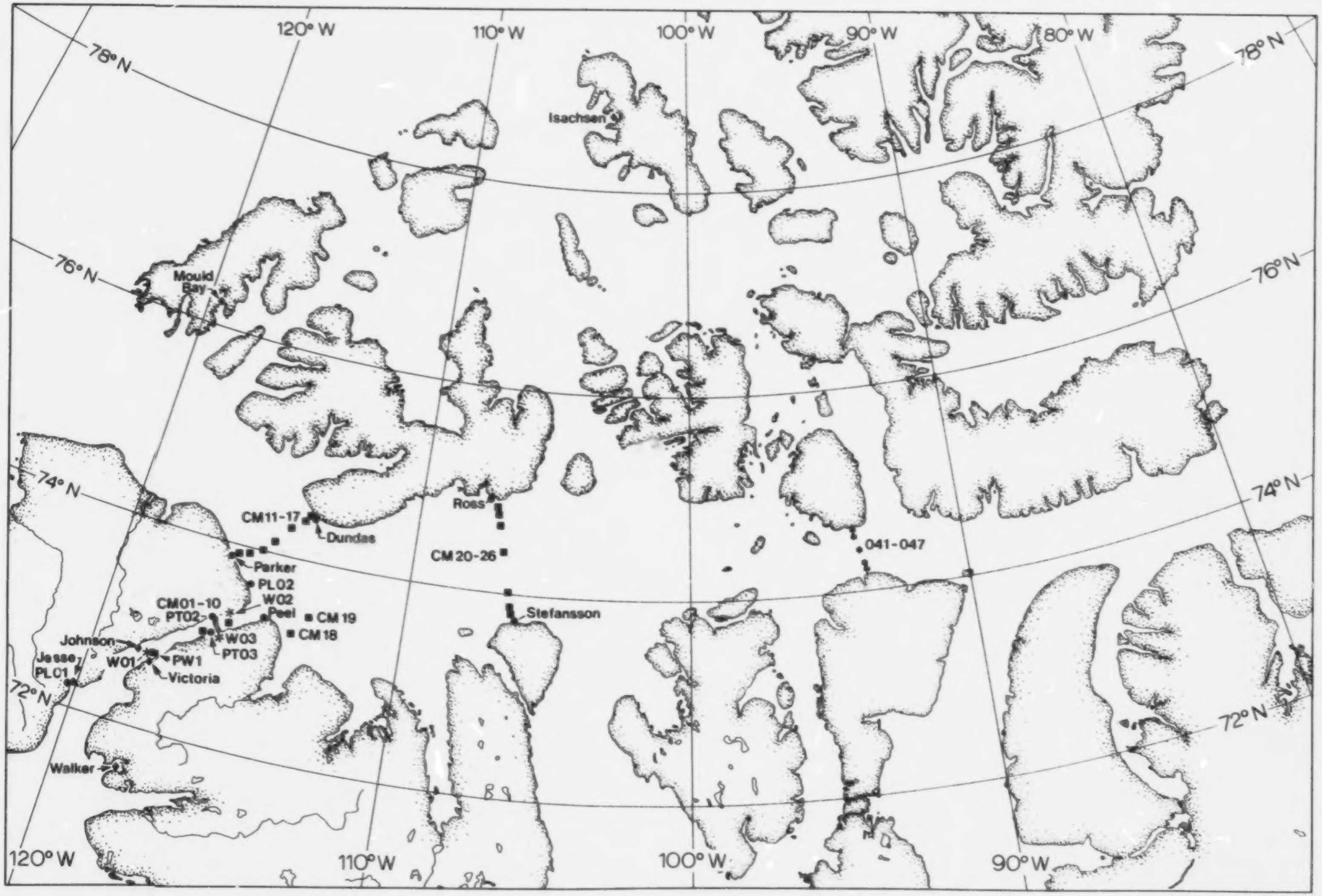

Figure 2. Location of recording instrumentation moorings throughout the Arctic Archipelago in 1982 (squares and triple lines - current meters; dots - tide gauges; asterisks - weather stations; stars and diamonds - current meters and tide gauges from concurrent studies by other agencies.)

(DFO-Central: seafloor water pressures and currents). The Canadian Hydrographic Service maintains tide stations at Cape Parry and Resolute Bay, and in 1982/83 maintained stations at Mould Bay, Isachsen and Auldhild Bay. Most of these moorings are indicated by star symbols in Figure 2.

The study area has not previously been extensively investigated due to its remoteness and to the difficulty of ship operations. The sea surface is completely frozen during most of the year, and is often ice-choked during the short navigation period. Previous oceanographic research in the Arctic Archipelago has been tabulated by Fissel, Knight and Birch (1984). The earliest significant collection of oceanographic data was accomplished from ships in summer during the 1950's and 1960's. These data were sufficient to delineate the regional water-mass characteristics. In 1976 and 1977, direct current measurements were made in Byam and Austin Channels and Crozier and Pullen Straits by the Institute of Ocean Sciences. In 1977 and 1978 investigators from the Physical Oceanographic Group of the Canada Centre for Inland Waters completed a number of current-measurement transects across Viscount Melville Sound, Prince of Wales Strait, and adjacent channels (Peck, 1978 and Prinsenberg, 1978). Current data across the western end of Viscount Melville Sound were gathered in 1979 as part of the Polargas Project (1979). A number of tidal height measurements were made during 1979 and 1980 as part of the Bridport Inlet studies by IOS. The Canadian Hydrographic Service also made extensive tidal height measurements in 1977, and an additional tidal height record was obtained as a part of the Polargas program in 1979.

The present study involved measurements by CTD probe, recording current meters, tide gauges, and meteorological stations. This report deals with the recording instrument measurements. Section 2 describes the physical setting and bathymetry of the study area and the mooring locations during 1982/1983. Section 3 recounts the logistics, equipment used, and the timing of the measurements, while Section 4 deals with the data processing procedures. The data are presented as time-series plots in the Appendix.

2. PHYSICAL SETTING AND STATION LOCATIONS

2.1 Arctic Archipelago

The Canadian Arctic Archipelago consists of a large group of islands lying on the extensive polar continental shelf of North America (Figure 1). The Archipelago extends roughly 1500 kilometers between the 68° and 82° North latitude and about 2700 kilometers between 60° and 130° West longitude (at 70° North). These islands are bounded to the north and west by the Arctic Ocean and the Beaufort Sea respectively, to the south by the mainland of the North American continent and to the east and southeast by Nares Strait, Baffin Bay, Davis Strait, and Labrador Sea. For convenience, the Archipelago is often divided into three sections from north to south as follows: the Sverdrup Basin lying within the Queen Elizabeth islands (i.e., all islands north of Parry Channel); Parry Channel, consisting of M'Clure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound; and the "Southern Channels" comprising Amundsen Gulf, M'Clintock Channel, the Gulf of Boothia, and other, lesser waterways.

2.2 General Bathymetry

The channels and basins throughout the Archipelago are in general substantially shallower than the major adjoining oceanic basins. The continental shelf effectively limits free passage of water to maximum depths of about 450 meters into Sverdrup Basin, to about 380 metres into M'Clure Strait, and to about 360 meters into Amundsen Gulf. To the east, Baffin Bay has depths up to 2300 meters, but the sill in Davis Strait (to the south of Baffin Bay) limits deep water exchange with the North Atlantic to depths of less than 700 meters. Another shallow entrance (50 meters) to the Archipelago from the North Atlantic exists through Hudson Strait, Foxe Basin, and Fury and Hecla Strait in the south. The deepest continuous passage through the Archipelago exists through Parry Channel and has a limiting sill of 125 meters in Barrow Strait. The passageways connecting Sverdrup Basin to the southern channels (M'Clure Strait, Viscount Melville Sound, Barrow Strait, etc.) are in general constricted by shallow sills on the order of 100 meters in depth. South of Parry Channel depths are characteristically shallow (mostly less than 200 meters) with the exception of some deeper areas of greater than 400 meters extending into Prince Regent Inlet from Lancaster Sound.

2.3 Mooring Locations and Local Bathymetry

The Northwest Passage field study in 1982 concentrated on the western portion of the Northwest Passage. The study area was bounded on the north by Melville Island, on the east by the 106° West meridian (approximately), on the south by Victoria Island, Amundsen Gulf and the northeast corner of Banks Island, and on the west by a line across the east end of M'Clure Strait between Melville Island and Banks Island. Due to the large size of the area studied (about 50,000 square kilometres) only near-surface currents were measured systematically over the area, and even for the surface-measurement array, mooring spacing was substantially greater than internal deformational and topographic scales of variability. In anticipation of shoreline "hugging" baroclinic flows, meters were more closely spaced near shores. Two complete transects and one partial transect were instrumented in Parry Channel, and one transect in Prince of Wales Strait (see Figure 2). In an attempt to resolve flows through the latter transect, current meters were deployed there at an average spacing of less than 2 km. Recording pressure gauges were deployed at the landfall positions of each transect. In Prince of Wales Strait, these gauges were calibrated and moored very precisely in the expectation that cross-channel pressure differences could be measured with sufficient accuracy that mean channel flow could be estimated using the geostrophic approximation. To aid in the interpretation of wind-driven channel flow, recording anemometers were deployed during the summer of 1982 at 3 locations in Prince of Wales Strait. Vertical variation of current was measured at two locations on the M'Clure Strait transect.

Concurrent measurements of current and seafloor pressure were acquired by the Canadian Hydrographic Service in Prince of Wales Strait, M'Clure Strait and Viscount Melville Sound, and by the Bayfield Laboratory for Marine Science and Surveys in Barrow Strait. Farther afield the Canadian Hydrographic Service made seafloor water-pressure measurements at Mould Bay, Isaachsen, Auldhild Bay and Pond Inlet, in addition to continuing longterm measurements at Cape Parry, Alert and Resolute Bay. These locations are plotted, where possible, in Figure 2.

Instrument location, depth, type, serial number, recovery success and observational period are tabulated for this program and for concurrent studies in Table 1.

In the following table, CCIW = Canada Centre for Inland Waters, T and C = Tides and Currents Section of Department of Fisheries and Oceans, CHS = Canadian Hydrographic Service.

Table 1. Summary of Recording Instrument Records

Region	Site	S/N	Latitude	Longitude	Type	3 mos.	12 mos.	Depth (m)	Data Recovery/ Remarks
Prince of Wales Strait	PW1	2693	72°47.1'	117°49.7'	RCM	✓		10	✓
"	CM01	3395	73°15.7'	116°16.6'	RCM	✓		20	✓
"	CM02	5475	73°14.6'	116°16.6'	RCM	✓		20	✓
"	CM03	3228	73°13.5'	116°15.8'	RCM	✓		20	✓ short record
"	CM04	0972	73°12.4'	116°13.8'	RCM	✓		20	✓ short record
"	CM05	5474	73°11.6'	116°15.0'	RCM	✓		20	✓
"	CM06	2470	73°10.6'	116°12.7'	RCM	✓		20	✓
"	CM07	1929	73°09.2'	116°09.7'	RCM	✓		20	✓
"	CM08	2468	73°08.7'	116°08.0'	RCM	✓		20	✓ 2 changes in ref. direction
"	CM09	3388	73°05.0'	116°34.7'	RCM	✓		20	✓
"	CM10	1935	73°12.1'	115°58.1'	RCM	✓		20	✓
M'Clure Strait	CM11	1936	73°55.7'	116°08.9'	RCM	✓		18	✓
"	CM11	3386			RCM		✓	80	x lost
"	CM11	6003			RCM		✓	232	x lost
"	CM12	5456	73°56.2'	115°51.6'	RCM	✓		18	✓
"	CM13	5471	73°59.9'	115°27.7'	RCM	✓		18	✓
"	CM14	5472	74°10.0'	115°02.0'	RCM	✓		18	✓
"	CM15	2466	74°17.7'	114°30.0'	RCM	✓		18	✓
"	CM16	5473	74°24.9'	114°00.0'	RCM	✓		18	✓
"	CM16	3385			RCM		✓	75	x lost
"	CM16	6004			RCM		✓	225	x lost
"	CM17	5390	74°26.9'	113°51.0'	RCM	✓		18	✓

Table 1. Summary of Recording Instrument Records (Continued)

Region	Site	S/N	Latitude	Longitude	Type	3 mos.	12 mos.	Depth (m)	Data Recovery/ Remarks
Peel Point	CM18	5391	73°19.8'	113°58.0'	RCM	✓		18	✓
"	CM19	1939	73°29.7'	113°19.3'	RCM	✓		18	✓
Viscount Melville Sound	CM20	1931	73°48.7'	106°25.9'	RCM	✓		18	✓
	CM21	3387	73°53.6'	106°30.0'	RCM	✓		18	✓
"	CM22	1930	74°00.8'	106°35.8'	RCM	✓		18	✓
"	CM23	3278	74°20.6'	106°51.1'	RCM	✓		18	x instr. malf'n.
"	CM24	1932	74°41.1'	107°06.3'	RCM	✓		18	✓
"	CM25	5361	74°48.0'	107°11.0'	RCM	✓		18	✓
"	CM26	5389	74°51.2'	107°14.0'	RCM	✓		18	✓
Barrow Strait	041		74°36.2'	94°02.8'	RCM	✓		10	✓ CCIW
"	042		74°34.0'	94°01.1'	RCM	✓		10,50,115	✓ CCIW
"	044		74°24.1'	93°54.7'	RCM	✓		10,50,142	✓ CCIW
"	046		74°13.3'	93°38.3'	RCM	✓		10,50,150	✓ CCIW
"	047		74°11.7'	93°35.3'	RCM	✓		10	✓ CCIW
Prince of Wales	Walker	090	71°37'	117°52'	TG	✓			✓ T and C
"	Jesse	056	72°15'	120°09'	TG	✓			✓ T and C
"	deSalis	021	71°26'	121°32'	TG	✓			✓ T and C
"	Victoria		72°41'	118°00'	TG	✓			✓ CHS
"	Johnston		72°45'	118°27'	TG	✓			✓ CHS
"	PL01	0092	72°14.1'	120°12.8'	TG12A		✓	17m	✓
"	PL02	0088	73°38.5'	115°34.3'	TG12A		✓	17m	x lost
"	PT02	0093	73°15.1'	116°28.0'	TG12A		✓	17m	x duplicates 0089
"	PT02	0089	73°15.1'	116°28.0'	TG12A		✓	17m	✓
"	PT03	0087	73°05.0'	116°22.5'	TG12A		✓	17m	✓
Amundsen Gulf	KingsBay	239	70°44'	117°45'	TG	✓			✓ T and C
"	Albert	058	70°41.8'	114°16.3'	TG	✓			✓ T and C
"	Bell Is.	086	69°38'	117°00'	TG	✓			✓ T and C

Table 1. Summary of Recording Instrument Records (Continued)

Region	Site	S/N	Latitude	Longitude	Type	3 mos.	12 mos.	Depth (m)	Data Recovery/ Remarks
M'Clure Strait	Parker	0158	73°51.8'	116°15.0'	TG	✓			✓ CHS
"	Dundas	0053	74°28.2'	113°46.0'	TG	✓			✓ CHS
Peel Point	Peel	0223	73°22.8'	114°34.0	TG	✓			x CHS, lost
Viscount	Ross	0366	74°56.5'	107°29.0'	TG5A	✓			✓
Melville Sound	Stefansson	0080	73°44.6'	106°20.8'	WLR5A	✓			✓
Prince of	W01	0374	72°46.5'	118°01.0'	WX	✓		-3	✓ weather station
Wales Strait	W02	0191	73°06.4'	116°09.4'	WX	✓		-3	✓ weather station
"	W03	0134	73°22.0'	115°46.0'	WX	✓		-3	✓ weather station
Auldhild Bay					TG12A		✓		✓ CHS
Isachsen					TG12A		✓		x CHS, instr. malf'n.

The bathymetry of the channels in the vicinity of the instrument moorings is shown in Figures 3 to 6. Figure 3 shows the western end of Viscount Melville Sound (RCM moorings 11-17) to have fairly steep sides and a flat bottom at about 400 m depth. The bathymetric contours in the middle section of the study area (RCM moorings 18-19) indicate shallow water (200m) in the southern half of the channel. Figure 4 shows the bathymetry at the eastern boundary (RCM moorings 20-26) to be smoothly sloping from the north and the south, with the deepest point (about 500m) occurring at about one third of the width from the south shore. The square and triangular symbols in this figure denote 1982 and 1983 moorings respectively. The bathymetry of Prince of Wales Strait is shown in Figures 5 and 6. It is characterized in a southwesterly direction by, successively, a sill of about 50 metres depth near the northeastern end of the strait, a basin of about 150m depth, a laterally constricted sill of about 100m depth near mooring PW1, a basin of 150m depth and another 100 m sill near 72°15'N. South of this sill lies a basin 190m deep, separated from Amundsen Gulf by a 155m sill (not shown in Figure 6). Anemometer towers were placed on the smaller of the two rugged Princess Royal Islands (the larger rises to 54m in the centre of the strait), on gently sloping terrain 1 km inland on Victoria Island near RCM8, about 40m above sea level, and on more rugged terrain 1.5 km inland on Banks Island near 73.4°N, about 35m above sea level. Land elevations exceeding 300m occur within 30 km along both sides of the strait.

3. DATA COLLECTION

3.1 Instrumentation

In total, 31 recording current meters and 14 recording pressure gauges were deployed in March and April of 1982 within the study area described in Section 2.3. Of the current meters, 27 were suspended from the ice for a deployment of between one and three months at shallow depth (10-20m). These meters were Aanderaa Instruments Ltd. RCM4's, modified at the Institute of Ocean Sciences to the 'vane-follower' configuration described below. The remaining 4 current meters were also Aanderaa RCM4's, but deployed in the standard 'large vane' configuration. These four meters were used on the 12-month deployments in M'Clure Strait, where stable ice for suspension could not be expected throughout the deployment. Mesotech acoustic releases (Model 501AR) were used to secure the two taut-line subsurface moorings in M'Clure Strait. Recording pressure gauges were manufactured by Aanderaa Instruments, Ltd. (a variety of models as noted in Table 1: TG3A, TG4A, WLR5A) or by Applied Microsystems, Ltd. (TG12A). All gauges used the Parascientific, Inc. Digiquartz pressure transducer, with a variety of full-scale pressure ranges. Three recording anemometers were deployed in June 1982. These used data loggers and sensors for speed, direction and air temperature, manufactured by Aanderaa Instruments, Ltd. The air-temperature sensors were platinum-resistance thermometers, shielded against radiation but reliant on natural ventilation. Meteorological sensors were mounted on a 3m weighted tripod made of aluminum tubing.

Special modification to the RCM4's was as follows: Two or more of the resistors in each of the bridge circuits for temperature and conductivity ratio were exchanged for values yielding 10-bit resolutions of about 0.005°C and 0.00016 respectively, and ranges centred on those of interest. For temperature this range was typically (-2.5°C, +2.5°) and for salinity

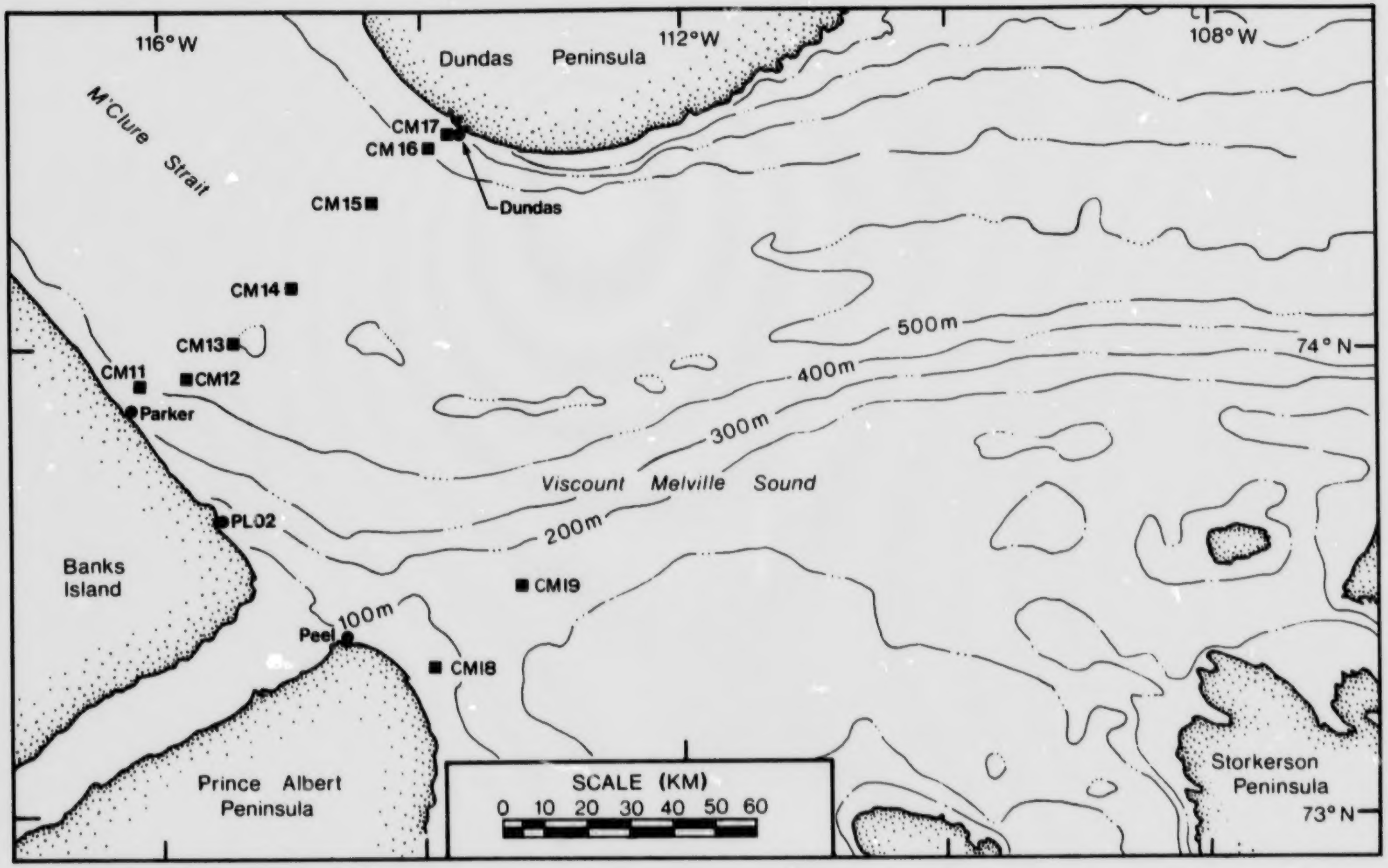

Figure 3. Bathymetry of the western part of Viscount Melville Sound (squares - current meters; dots - tide gauges.)

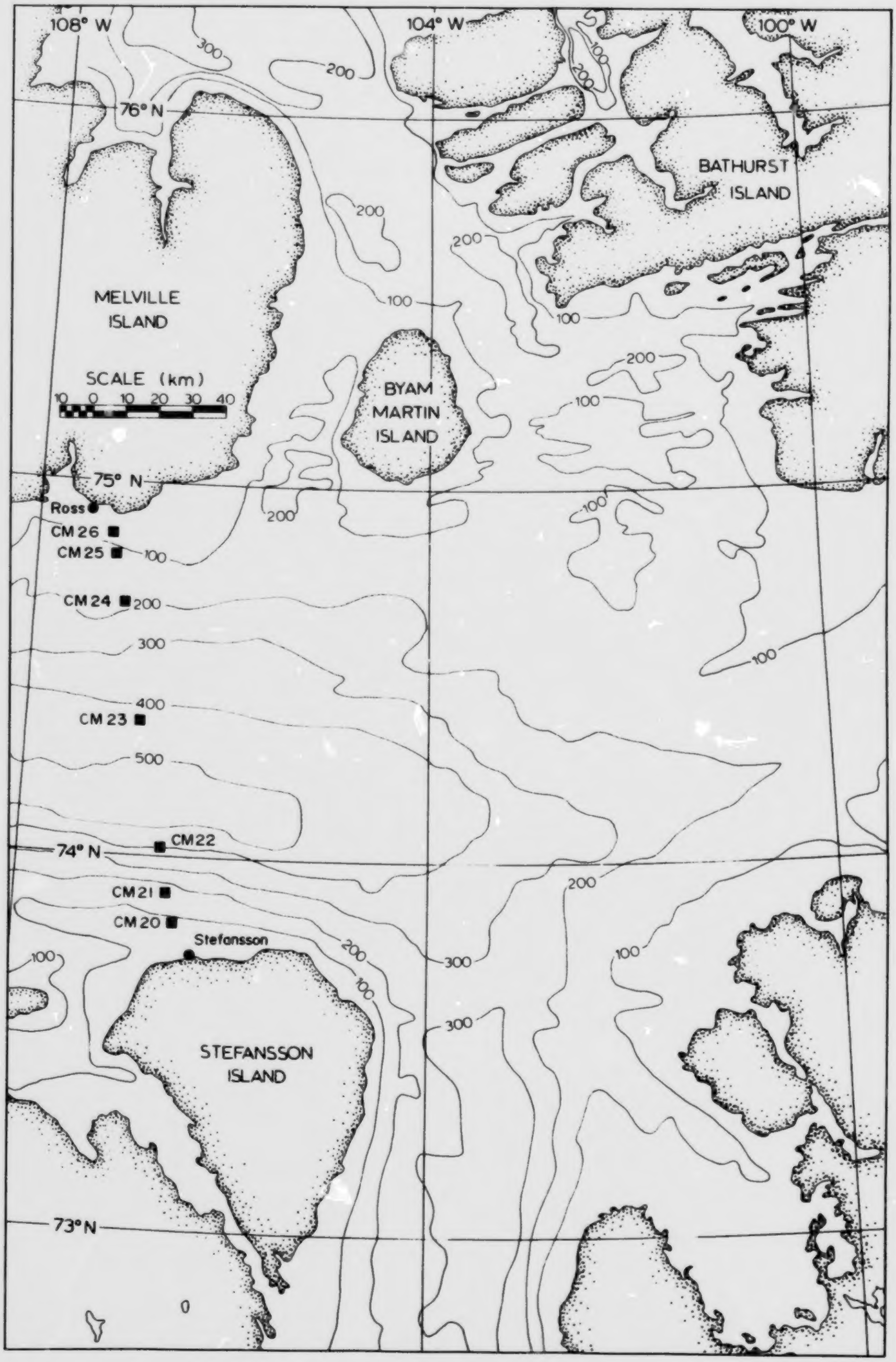

Figure 4. Bathymetry of the eastern part of Viscount Melville Sound (squares - current meters; dots - tide gauges.)

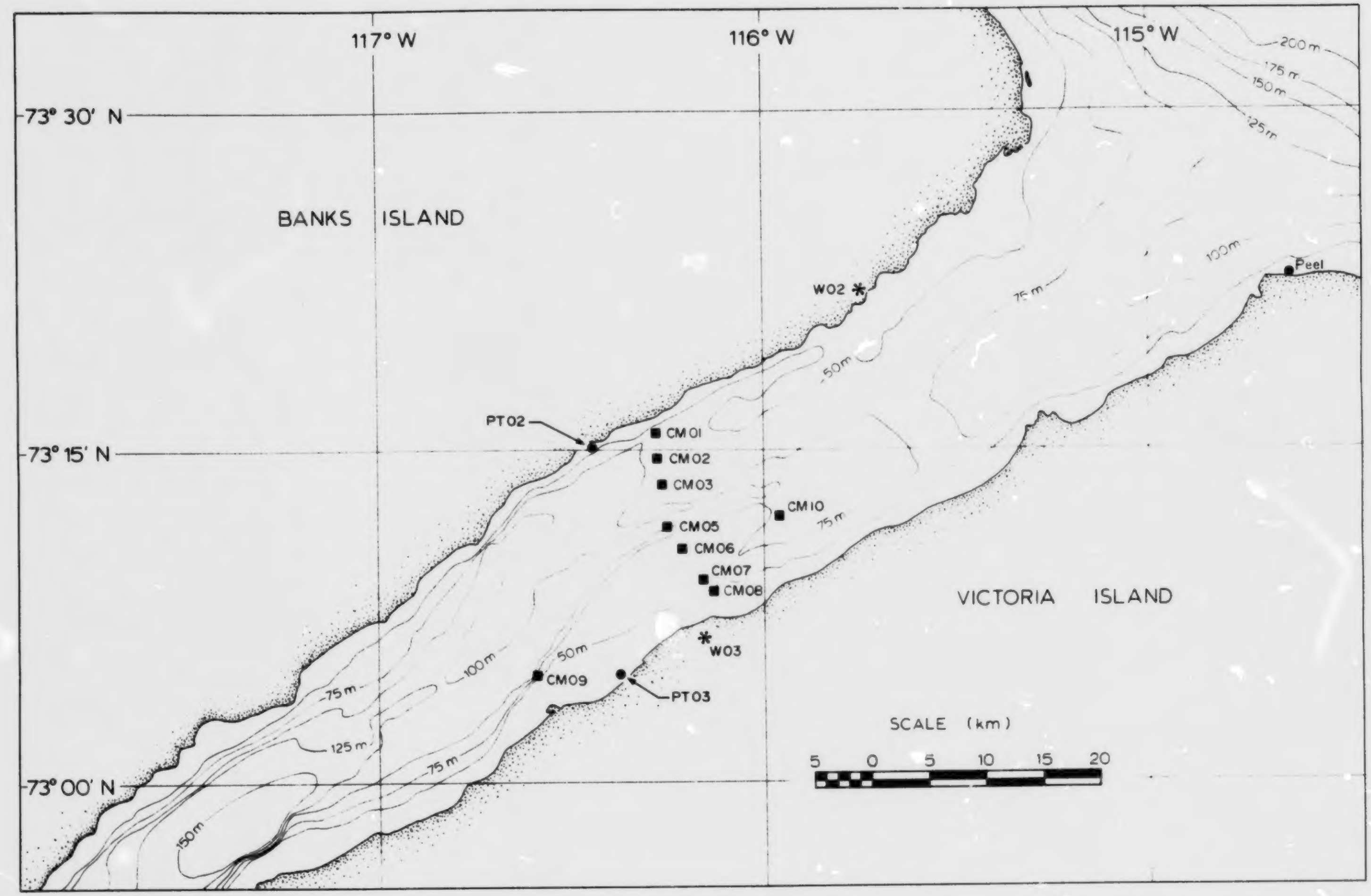

Figure 5. Bathymetry of the northeastern part of Prince of Wales Strait (squares - current meters; dots - tide gauges; asterisks - weather stations.)

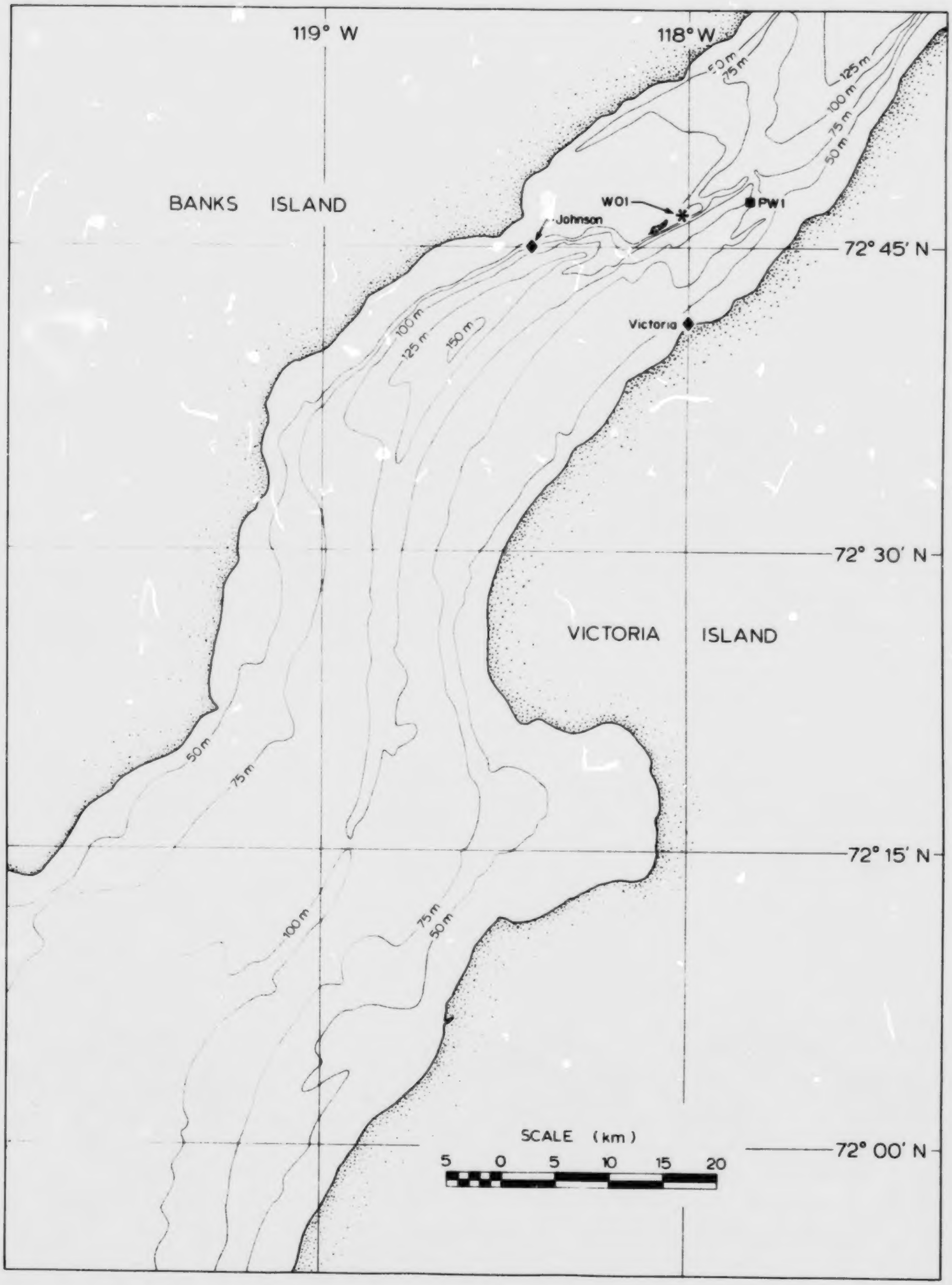

Figure 6. Bathymetry of the southwestern part of Prince of Wales Strait (square - current meters; asterisk - weather station; diamonds - concurrent tide gauges by other agencies.)

approximately (29, 35). Resolution in salinity was about 0.006. Aanderaa current meters in the 'standard' configurtion were deployed in lengthened pressure cases in order to eliminate the sensitivity of the geomagnetic-field-sensing compass in the base of the pressure case to the moving magnets of the electromechanical data encoder. The horizontal component of the geomagnetic field in M'Clure Strait is only 2400-2900nT. Long cases permit the installation of two batteries, desireable for long data recordings at low water temperature. Lengthened cases were used also for the current meters deployed in the 'vane-follower' configuration. In the 'vane-follower' configuration, a small (15.5 cm high by 7.8 cm wide) vane was suspended beneath the pressure case in mounts held by 3 stainless steel rods about 6 mm in diameter. The vane was neutrally buoyant in seawater. The field from two magnets mounted above the vane and free to turn with it was adequate to orient the compass within the case. In this way current direction relative to the case was measured, while geographic orientation of the case was established at deployment and maintained until recovery.

Three methods were used for positioning moorings. Pressure gauge moorings nearshore were sited by sextant relative to natural landmarks, or to markers set up for the purpose. Moorings more than a few hundred meters from shore were positioned using a GNS-500A VLF/Omega navigation system installed on the deploying aircraft and initialized at nearby geodetic survey points. This allowed positioning to within a 500 m radius. The bottom-founded moorings in M'Clure Strait, and the closely spaced moorings in Prince of Wales Strait were positioned to an accuracy of a few meters using microwave transponders deployed at known locations for this purpose. In M'Clure Strait a DelNorte Trisponder system was used, and in Prince of Wales Strait a Decca MiniRanger system. Sites where moorings were to be recovered before the break-up of fast ice in summer were marked by empty 45-gal oil drums, and by radio beacons operating at 130 MHz (Novatech Designs Ltd., Model RF200). Sites where moorings were to be recovered one year later were marked by underwater acoustic beacons operating at 37 kHz (Johnson Laboratories, Inc., Model JL1).

3.2 Mooring Design, Deployment and Recovery

'Vane-follower' current meters were suspended from the sea ice on 1-inch hydraulic hose (see Figure 7). The hose was chosen because of its high torsional rigidity despite reasonable bending flexibility. Resistance to twisting was essential for maintaining a direction reference for current measurement. Meter depth was 18.5 m below the upper ice surface for instruments in Parry Channel and 20 m for those in Prince of Wales Strait (with the exception of site PW1 where the depth was 10m). The hose was terminated and bolted to a 1-inch aluminum pipe just below the ice. This 12-foot pipe, and a vinyl-coated cable within it passed through the ice inside a 10-foot pipe of polyvinyl chloride plastic (PVC). A rubber seal between the metal and PVC pipes at the lower end of the latter permitted the space between the pipes to be filled with a 50/50 ethylene-glycol/water solution. A crossbar at the top of the metal pipe held the weight of the mooring and allowed mooring orientation (and that of the current meter) to be established. The assembly was deployed through a 12-inch-diameter hole augered in the ice and allowed to freeze in. The plastic-coated cable was bolted to the oil-drum marker as a security measure. At the time of recovery, a 12-inch hole was augered beside the mooring and the crossbar on the mooring removed. The metal pipe was then lowered on the cable until well clear of the ice. At this point, the cable was

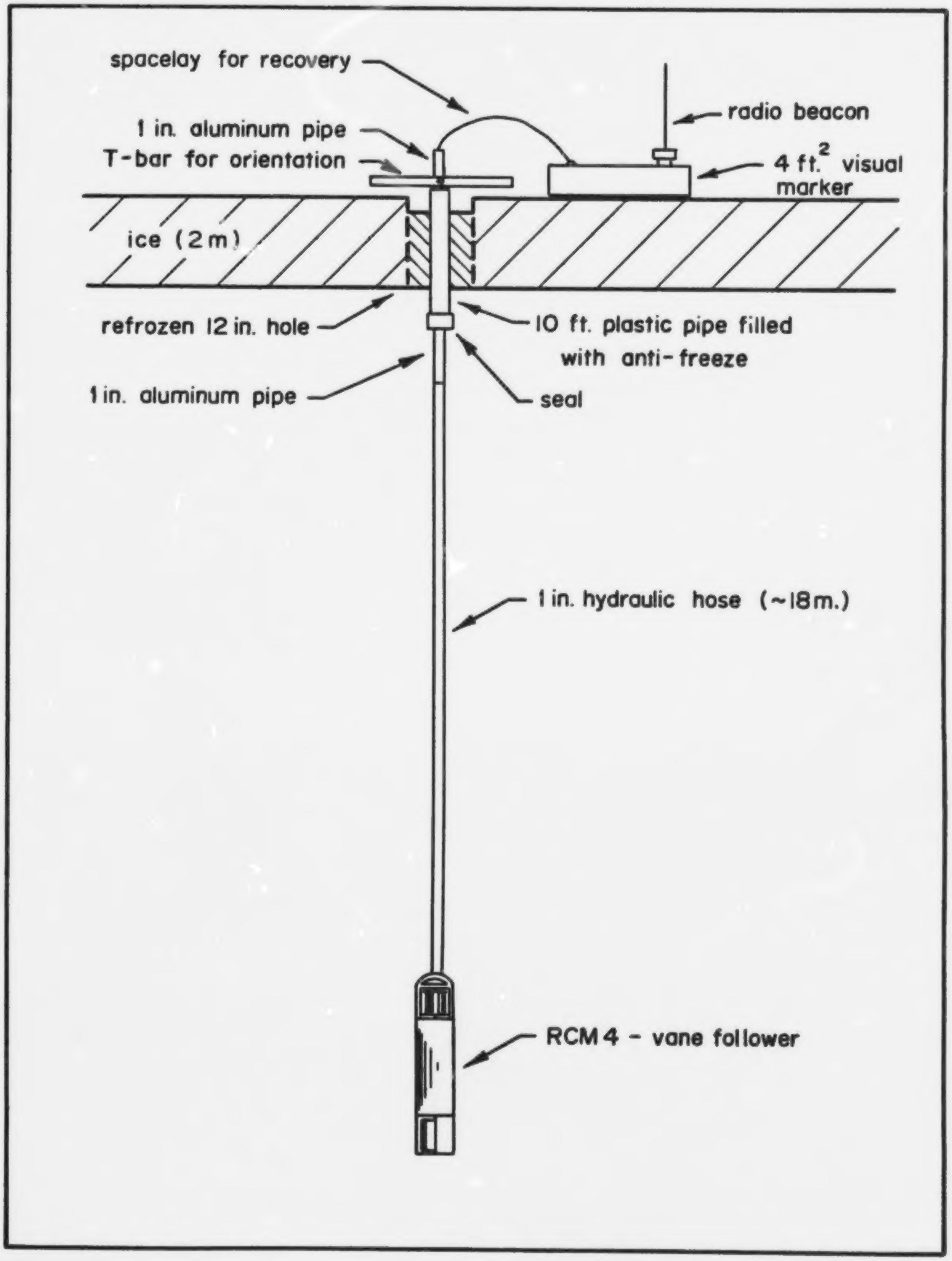

Figure 7. Vane-follower current meters suspended from the sea-ice on hydraulic hose.

hooked by a pole manipulated through the adjacent hole and the assembly pulled through this hole to the surface. The PVC pipe (still frozen in the ice) was abandoned. Simulation of the mooring response to flow using the model of Bell (1979) indicated that the vertical displacement of the current meter was only 0.2m with a 50 cm/s current.

Current meters in standard configuration were used at sites CM11 and CM16 in M'Clure Strait on taut-line bottom-founded moorings (see Figure 8). Flotation was provided by a single 28" diameter steel float (Ocean Research, Inc., Model SS28B). The principal mooring line was wire rope of 1/4" diameter. Current meters were isolated from the magnetic influences of the wire rope by 5-metre lengths of 3/4" polypropylene rope. Stainless steel shackles and pins and plastic thimbles were used in the vicinity of the current meters again to minimize magnetic disturbance. The large vanes of the current meters were hinged to enable deployment through a 30-inch diameter hole in the ice, and were latched up into the proper position when just beneath the ice. A single acoustic transponding release was used on each mooring. Current meters were positioned at depths of 75 m and 225 m. The deployment winch, quadripod, ice-hole melter and other mooring gear were designed and built at the Institute of Ocean Sciences both to meet the requirements of the task, and to be aircraft transportable.

Recording pressure gauges were moored in two ways. Those gauges required for tidal description, and short-term (1-3 month) deployment were strapped above a steel or lead ballast weight and lowered to an upright position on the seafloor (see Figure 9). Sufficient slack was left in the polypropylene rope to accommodate sea-level variations, and the rope was secured to the marker barrel on the ice. For recovery, a hole was augered in the ice adjacent to the in-frozen rope, the rope hooked and the instrument raised from the seafloor. For the gauges moored in Prince of Wales Strait over 12 months, a line could not be secured to the ice, and the requirement for vertical stability of the moorings was more stringent. To facilitate recovery, these gauges were deployed with a CUBA package (Polar Research Laboratories, Inc., Call-up-Buoy-Acoustic). Upon command from a surface hydrophone, this package released a tethered float with an attached acoustic beacon (Johnson Laboratories, Inc., Model JL1). This float was then located beneath the ice by triangulation on the beacon, hooked and the instrument pulled to the surface. To maintain good vertical stability, the package was not simply positioned on the seafloor, where it might have settled into the soft mud due to its weight and to the effects of current scouring. Instead, an aluminum stake was lowered to the sea floor on a pipe string, and pounded about 1-1.5 m into the more consolidated deeper sediments by a weight lowered repeatedly down the pipe string. The weight was then retrieved, and the tide-gauge/release package lowered down to an upright position on the stake at the seafloor. The pipe string was subsequently disconnected from the stake, retrieved and deployment was complete (see Figure 10).

Mooring operations were conducted, interspersed with CTD work, between 21 March and 19 April 1982. Activity in Prince of Wales Strait and M'Clure Strait was supported out of a base camp set up by the Canadian Hydrographic Service at Johnson Point, while that in eastern Viscount Melville Sound was supported from the Panarctic Oils Ltd. supply base at Rae Point. Most operations were carried out from a chartered Bell 206L-1 helicopter, while caches of fuel and equipment were established in the working areas by deHavilland DHC-6 Twin Otter on ski/wheel gear.

Recovery of ice-secured instruments was accomplished between 19-24 June 1982, again using the Bell 206L-1 with Twin Otter support. At this time,

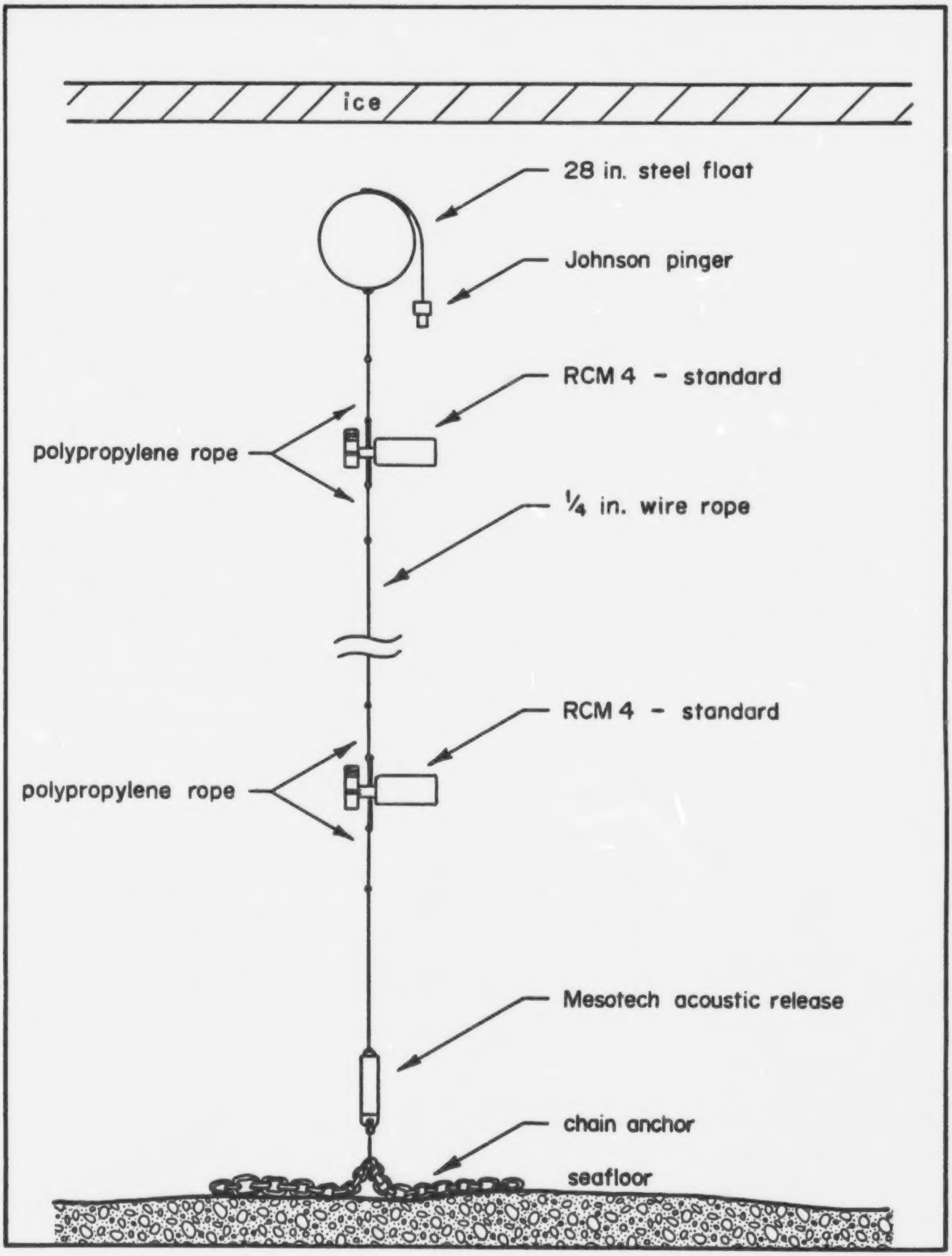

Figure 8. Standard configuration current meters on a taut-line mooring.

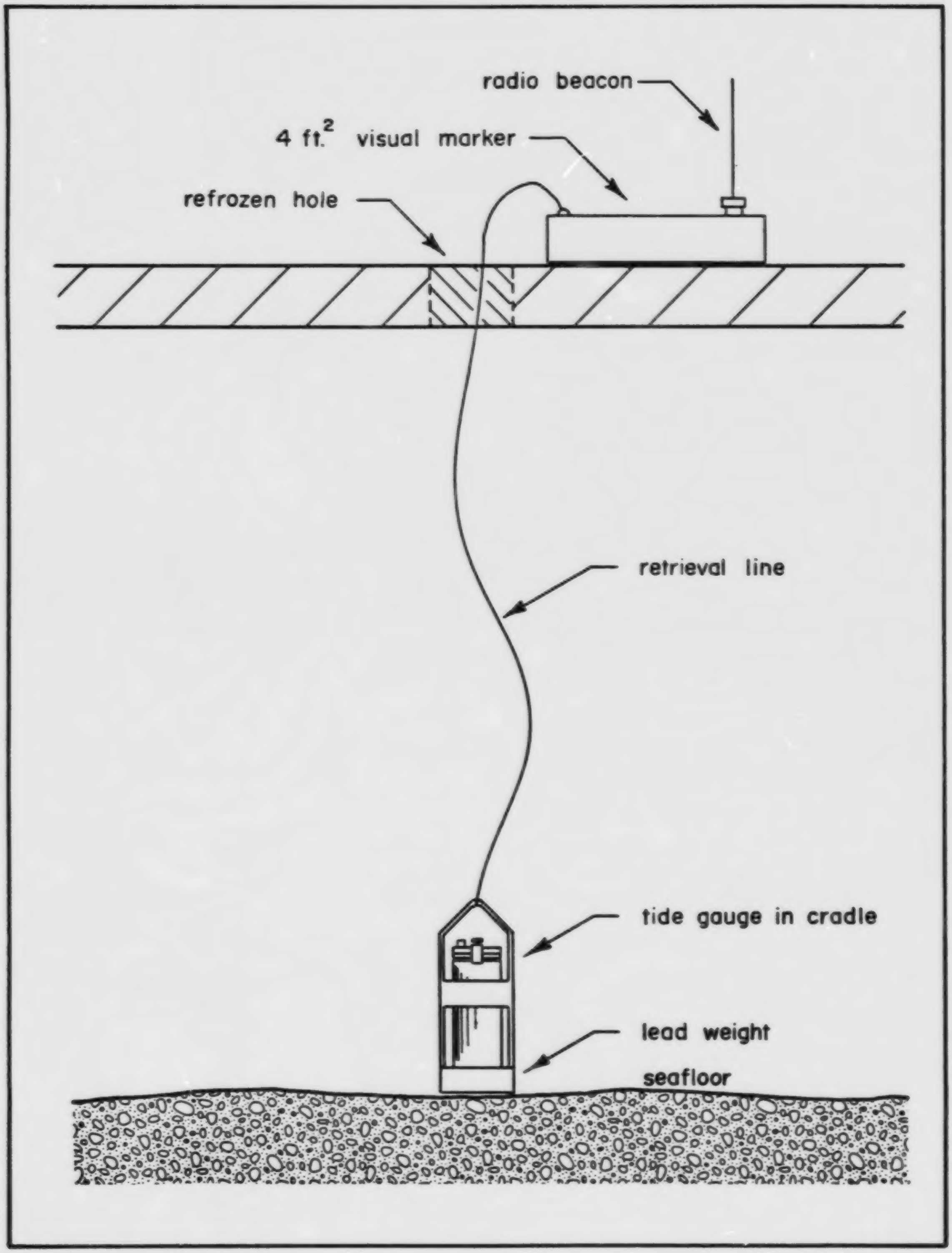

Figure 9. Mooring for short-term tide gauge deployment.

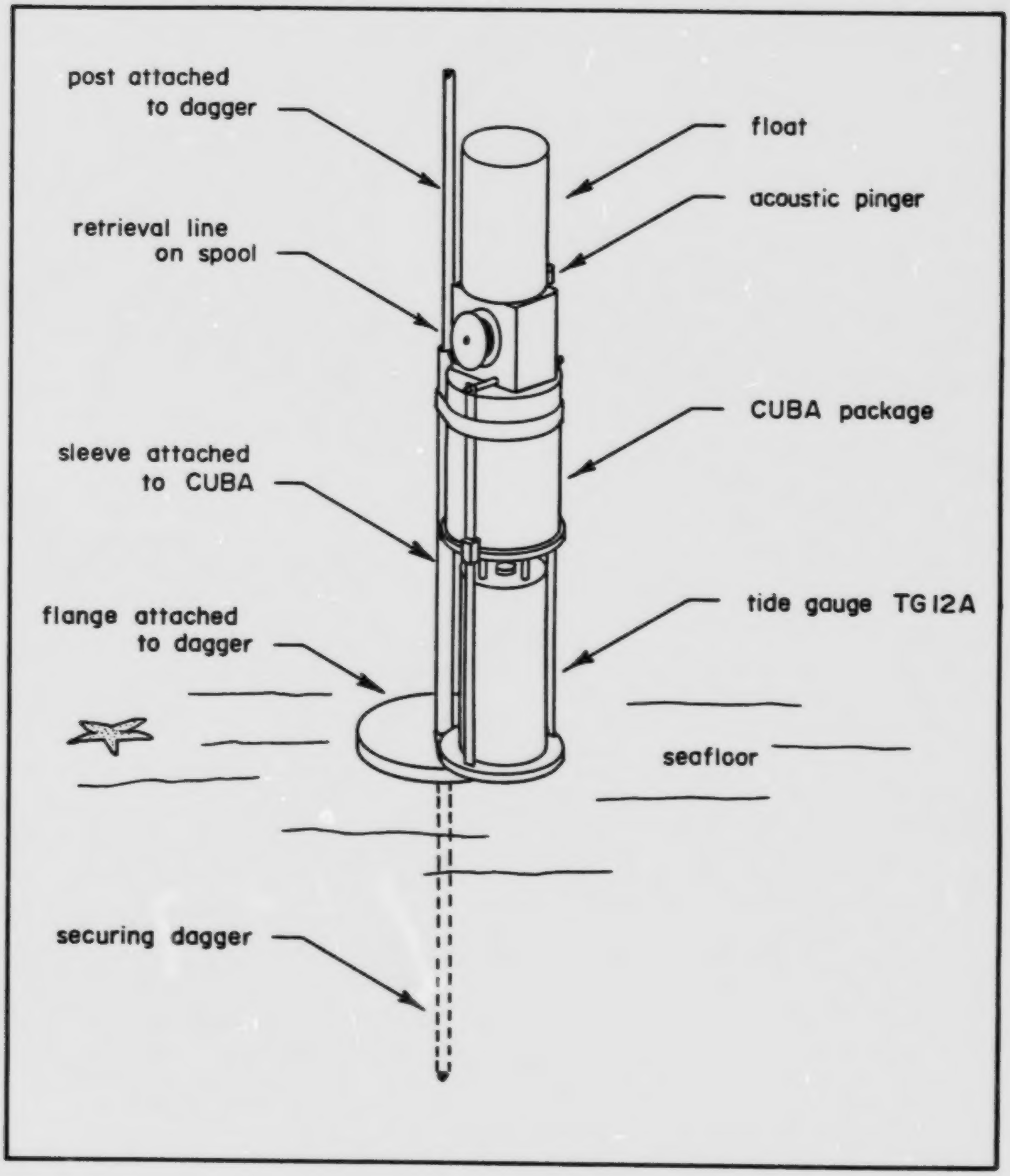

Figure 10. Mooring for long-term tide gauge deployment (CUBA system).

meteorological towers were deployed at the three sites in Prince of Wales Strait.

Retrieval of bottom-mounted instruments was attempted in late May 1983, using a Bell 205 helicopter for transport. Meteorological towers and pressure gauges in Prince of Wales Strait were recovered successfully, although for the retrieval of the latter, divers had to be used because of failure of the CUBA packages. The pressure gauge at Parker Point was not found. Heavy scouring of the seafloor (18 m depth) observed by divers at the site suggests that ice destroyed this mooring. Both current-measuring chains in M'Clure Strait were located and released. The chain at CM16 started to drift following release, and despite many hours spent tracking the acoustic beacon, the chain failed to lodge beneath the ice and it was eventually abandoned. Inadequate or partially flooded flotation is suspected. The chain at CM11 was found to have a non-functioning acoustic beacon, and the jarring effects of release on the beacon's seawater battery failed to re-activate it. Finding the chain on the basis of a release pinger several hundred metres deep proved fruitless, and this chain was also abandoned.

The timing of successful operational periods of the recording instrumentation is shown in bar chart of Figure 11.

3.3 Calibration

Current meters were deployed with sensors for current speed, direction, water temperature and conductivity. The speed sensors were not calibrated for this deployment, since experience has shown the calibration to be stable provided that rotor bearings are well maintained. Rotor thresholds were verified to be within tolerance by testing for rotation in response to a minimum torque specified by Aanderaa Instruments. It should be noted that in the 'vane follower' configuration, flow may approach the meter from any direction. (In the standard configuration flow is always at right angles to the rotor support yoke.) It has recently been established (Pite, 1986) that in some directions, the support interferes significantly with the rotor response to flow. As a result the rotor sensitivity is azimuthally non-uniform (see Figure 12). Since no correction for this effect was made in processing these data, it contributes an imprecision in speed of about ±7%.

In the 'vane-follower' configuration uncertainties in direction measurement arise from the following sources: nonlinearity in vane response to current; non-linearity in encoded compass reading to vane position; inaccuracy in carrying the reference direction up the 20 m of hydraulic hose and aluminum pipe from the instrument case to the crossbar at the surface; and inaccuracy in referencing the crossbar orientation to geographic north. The nonlinearity in vane response to current arises from the interaction of the flow with the 3 rods supporting the vane bearing (Pite, personal communication). Vane orientations aligned with a downstream support rod are avoided. Since no correction has been made for this effect in processing these data, an imprecision of about ±7° in direction is thereby contributed. The non-linearity in compass response to vane position arises from the interference of the geomagnetic field and any remnant magnetism in the instrument case with the magnetic coupling between the vane magnets and the compass, from any departure in concentricity between the vane and the compass pivots and from nonlinearities in the compass potentiometer. The combined effect of these factors was measured near the mooring sites before deployment (either at Johnson Point or Rae Point), and appropriate corrections (as large as 25° peak-to-peak) were made during processing. The uncertainty

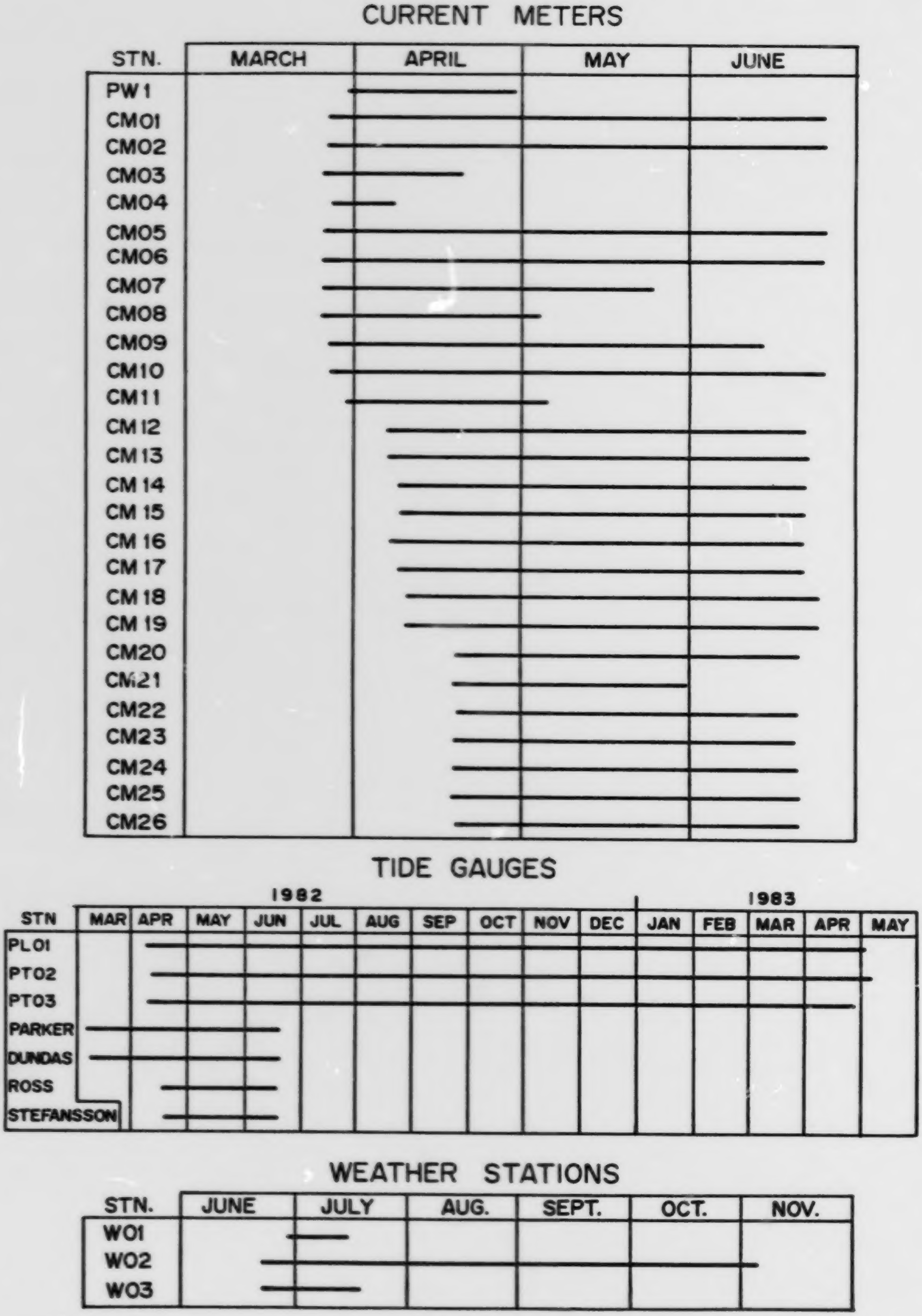

Figure 11. Bar chart of operational periods for recording instrumentation.

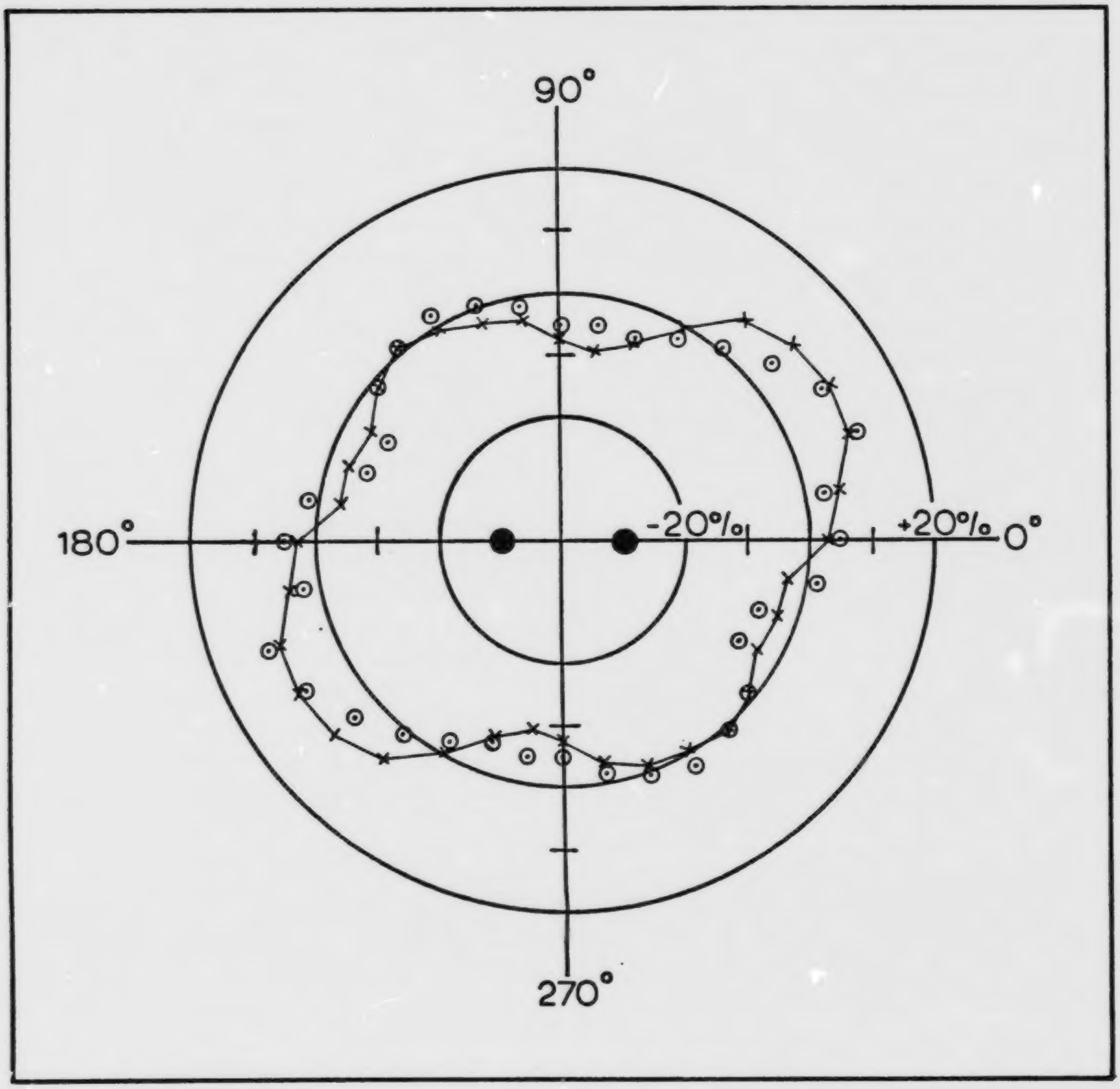

Figure 12. Plot of current meter rotor sensitivity versus azimuth for a two rod support configuration.

in these corrections contributes a further imprecision of ±3° to direction measurement. Difficulties in carrying the direction reference from the current meter to the crossbar produce an inaccuracy of about ±5°, while those in referencing the crossbar orientation to geographic north produce a further inaccuracy of about ±10°. Crossbar orientation was determined by aligning the crossbar with the aircraft whose orientation was determined by sun position, and tables.

Temperature sensors on the current meters were calibrated in a large insulated seawater bath whose temperature was controlled to within one or two millidegrees Celsius. Sensor output was determined at 6 or 7 temperatures spanning the range, and a cubic polynomial equation for temperature fitted. Bath checks before and after deployment, and *in situ* comparisons with output from a profiling CTD have verified that accuracy and precision equal the resolution of 0.005°C.

Conductivity sensors on the current meters were calibrated in the same bath at two or three different conductivities and a linear equation for conductivity ratio was fitted. Bath salinity was determined by analysis of samples on a Guildline AutoSal salinometer. Experience has shown that bath calibrations are not reliable predictors of *in situ* performance, for reasons which are not well understood. *In situ* comparisons with output from a profiling CTD at the moorings in Prince of Wales Strait showed RCM salinity offsets ranging as far as +0.13 from laboratory calibrations, with an average departure of +0.06. *In situ* comparisons at the other moorings were not as well controlled, but yielded similar values. Calibration equations were adjusted for all current meters in accordance with the *in situ* calibrations. Accuracy and precision in salinity measurement following adjustment are estimated to be 0.03.

Digiquartz pressure gauges with full-scale pressures exceeding 30 dbar were calibrated by Aanderaa Instruments Ltd., at a single fixed temperature (generally 0°C) by applying known pressures with a dead-weight tester (Ruska Model 2465-751-00). Output values at 10-20 different pressures were fitted to a polynomial equation with a precision of approximately 0.003% fs. Reproducibility of deadweight pressures was about 0.01 dbar. Their absolute accuracy depends on the care used in operation and on the attention paid to such factors as hydraulic heads and air bubbles in connecting tubing. A realistic estimate is 0.03 db.

The Digiquartz pressure gauges with full-scale pressures of 30 dbar were calibrated at the Institute of Ocean Sciences at six temperatures between -1.5°C and +20°C. Pressures were applied by a mercury column and measured using a reference gauges kept at 20°C throughout. All gauges were connected to the same pressure manifold, and particular care was taken to measure the differing hydraulic heads in tubing above pressure gauges and to purge this tubing of gas bubbles. Absolute pressure values from these gauges were thus somewhat improved, while relative values were more precise by about a factor of 3 than values from the higher range gauges. An equation with quadratic temperature dependence and cubic dependence on oscillator frequency was used to fit calibration data.

The estimated accuracy and precision of the current meter and tide-gauge sensors are tabulated in Table 2.

Table 2

Estimated Accuracy and Precision of Measurement

Instrument	Parameter	Accuracy	Precision	Resolution
RCM4	Speed (cm/s)	±2%	±7%	.05 cm/s
RCM4	Direction (°T)	±11°	±7°	0.4°
RCM4	Temperature (°C)	±.005	±.005	0.005
RCM4	Conductivity Ratio	±.0008	±.0008	0.00016
TG2A/3A	Pressure (db)	±0.03db	±.01db	0.001%fs
TG12A	Pressure (db)	±0.01db	±0.003db	0.001%fs
TG12A	Temperature (°C)	±.005	±.005	±.005

4. DATA PROCESSING

The first stage in processing the current meter data was the translation of the information from the original one-quarter inch magnetic tape onto a computer-compatible nine-track magnetic tape. This process was done at the Institute of Ocean Sciences using an HP2100 computer. The data were then read into the Institute's Univac 1100/60 computer for editing. The editing procedure involved timing checks, the truncation of irrelevant pre- and post-deployment data, and the replacement of occasional spurious measurements, or "spikes". Calibration formulae were then applied to the "N" numbers to produce values of the designated parameters, usually speed (cm/sec), direction (degrees True), conductivity ratio, temperature, and sometimes pressure. Salinity and density were then calculated. Salinity was calculated using the Practical Salinity Scale 1978 (Lewis, 1981). Density was presented as sigma-t, from the relationship,

$$\sigma_t = (\text{density } (\text{gm/cm}^3) - 1) \times 10^3$$

After the data had been converted to real values, they were stored on magnetic tape. Each file on a tape contains information from one instrument. The files begin with a header which indicates such things as instrument number, station location, and station designation. These are followed by up to eleven channels of calibrated data as follows:

channel 1 - time
2 - speed
3 - direction
4 - high resolution temperature
5 - salinity
6 - pressure
7 - conductivity ratio
8 - sigma-t
9 - low resolution temperature
10 - time code generator
11 - voltage reference

All channels were not always used in each instance.

Similar procedures were used to process the tide gauge and meteorological station data.

5. DATA PRESENTATION

The calibrated and corrected current meter data are presented in the Appendix as time series plots of current speed, direction, temperature, and salinity. Superimposed on the speed and direction traces with a heavier pen are low-pass filtered values of the same (tidal signal removed). One month of data is displayed per page.

For the tide-gauge measurements, only one month of representative data is shown.

The meteorological data are presented in their entirety as plots of wind speed and direction, with low-pass filtered data superimposed with a heavier pen.

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APPENDIX

Recording instrument data index and time-series plots.

RECORDING INSTRUMENT DATA INDEX

CURRENT METERS

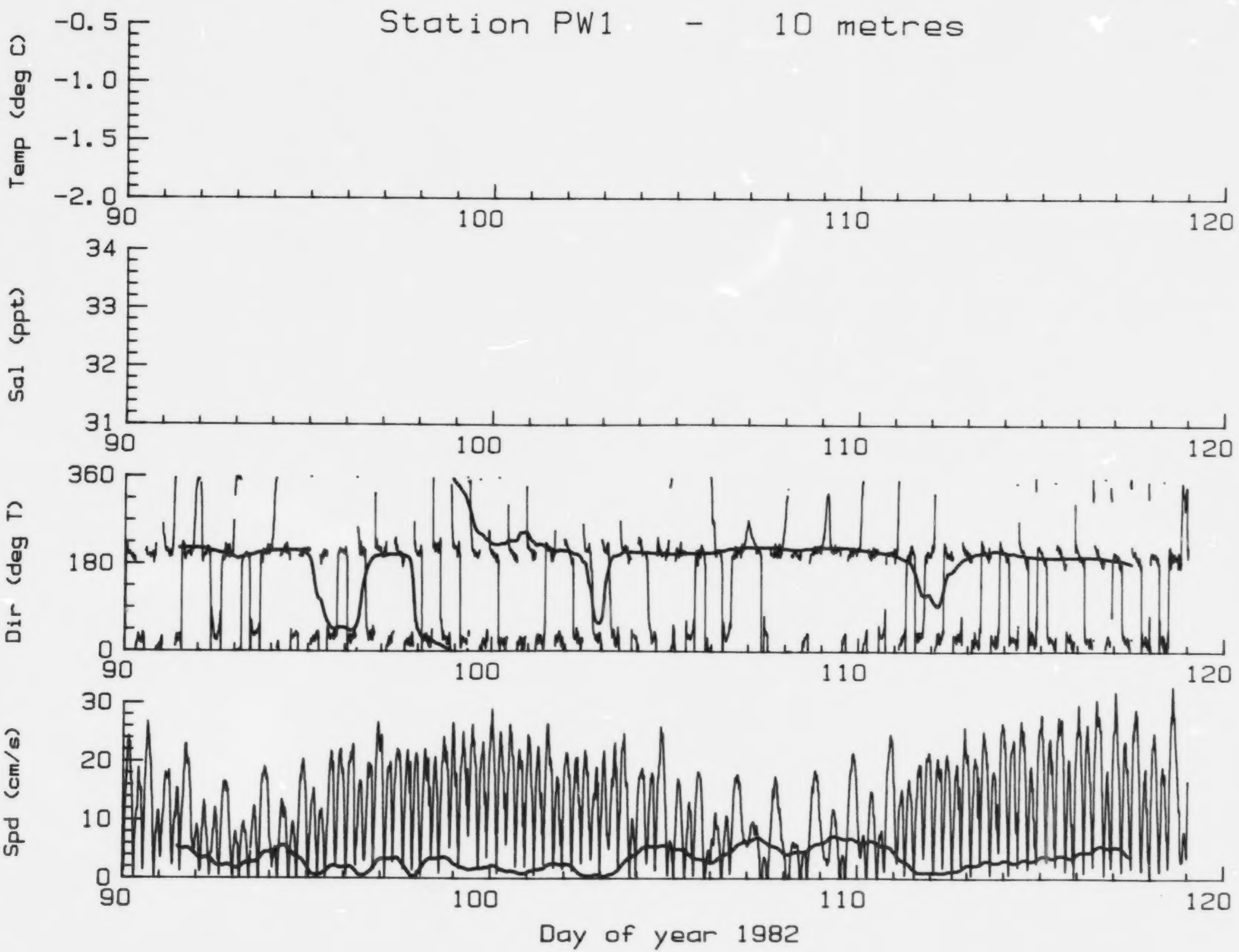
STATION	PAGE	STATION	PAGE	STATION	PAGE
PW1	29	CM09	58	CM18	86
CM01	30	CM10	62	CM19	89
CM02	34	CM11	66	CM20	92
CM03	38	CM12	68	CM21	95
CM04	40	CM13	71	CM22	98
CM05	44	CM14	74	CM23	101
CM06	48	CM15	77	CM24	104
CM07	52	CM16	80	CM25	107
CM08	55	CM17	83	CM26	110

TIDE GAUGES

STATION	PAGE	STATION	PAGE
PL01	113	Dundas	114
PT02	113	Ross	114
PT03	113	Stefansson	115
Parker	114		

WEATHER STATIONS

W01	116
W02	121
W03	127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Sal (ppt)
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33
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Spd (cm/s)
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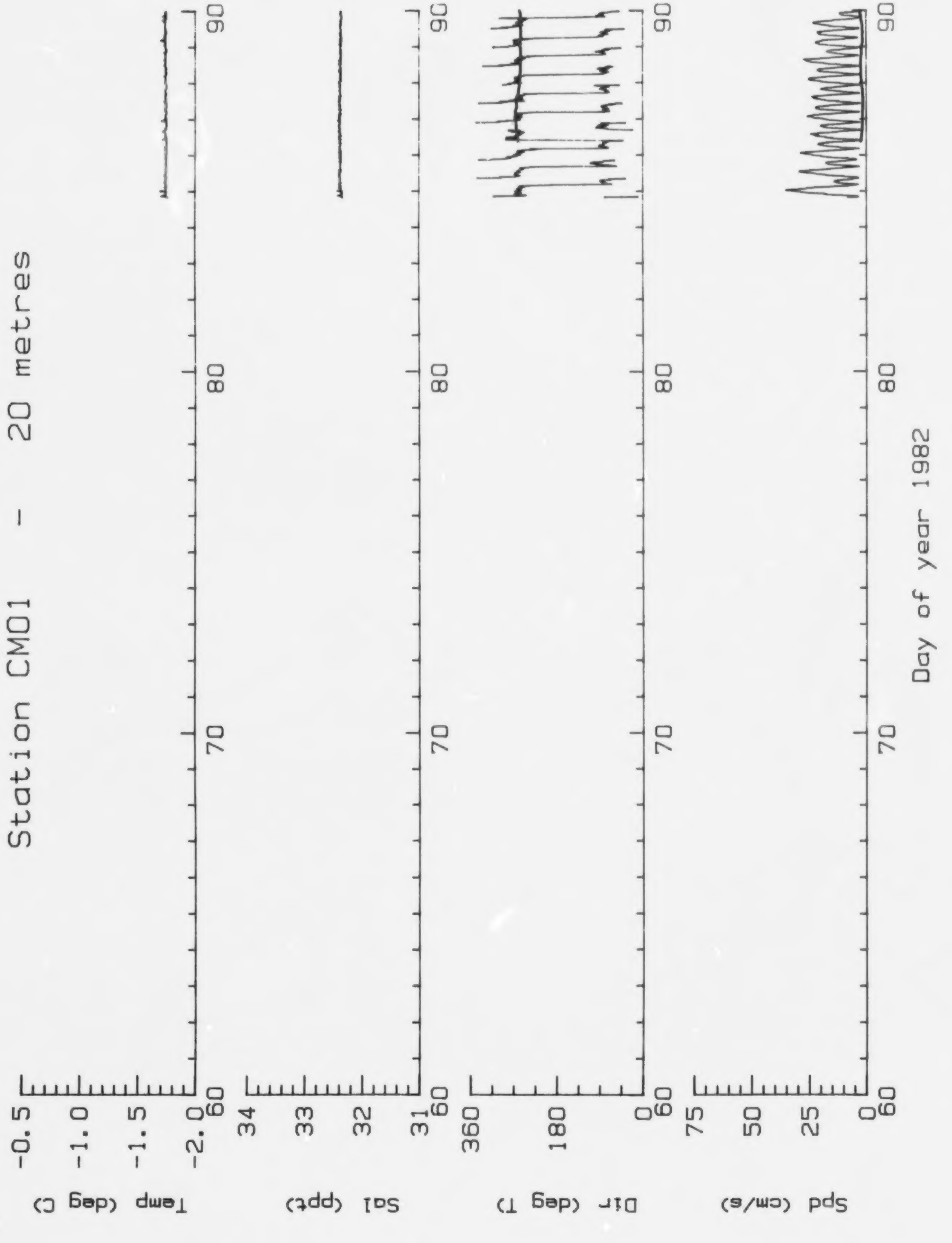
10
0
90
100
110
120
Day of year 1982



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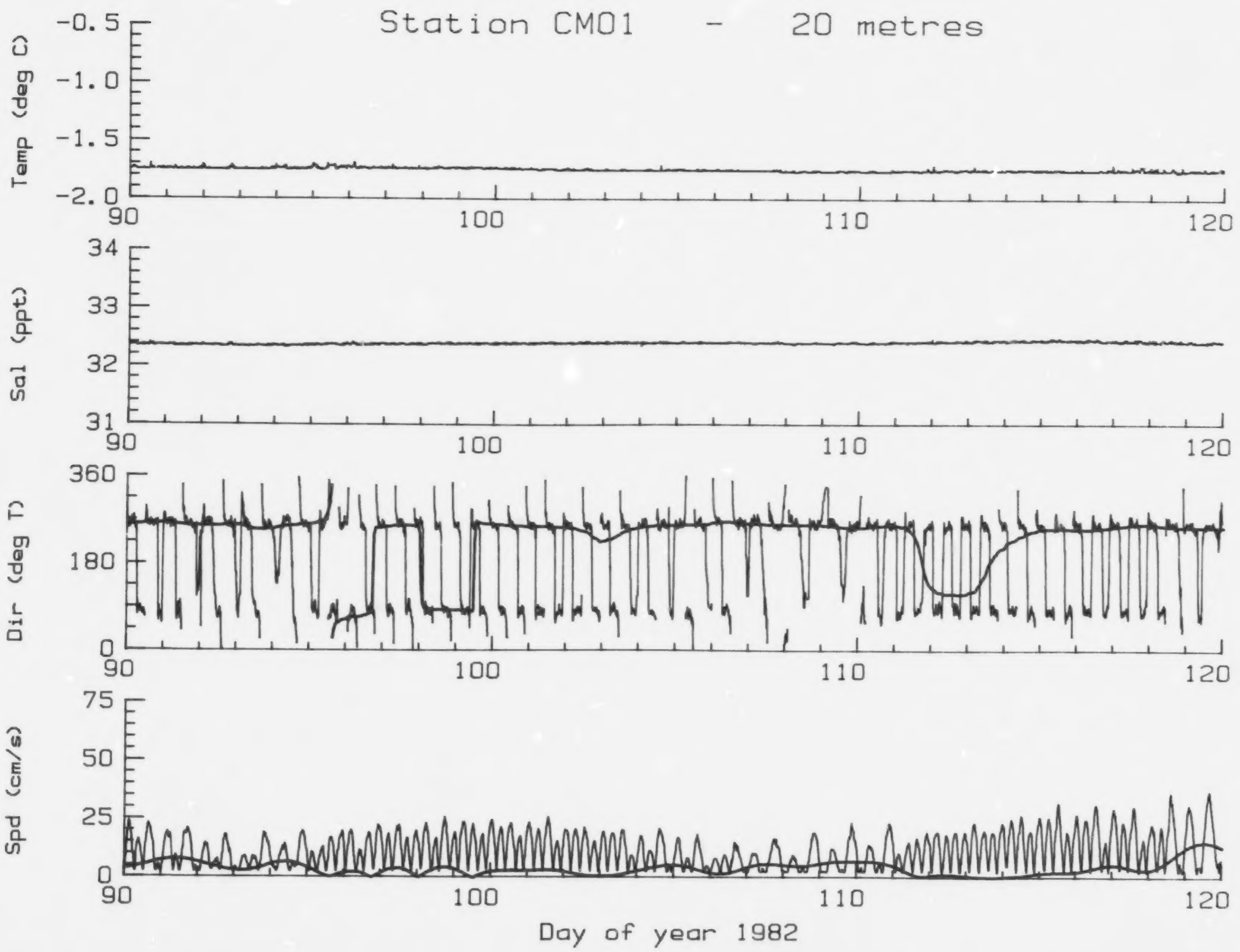
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Spd (cm/s)
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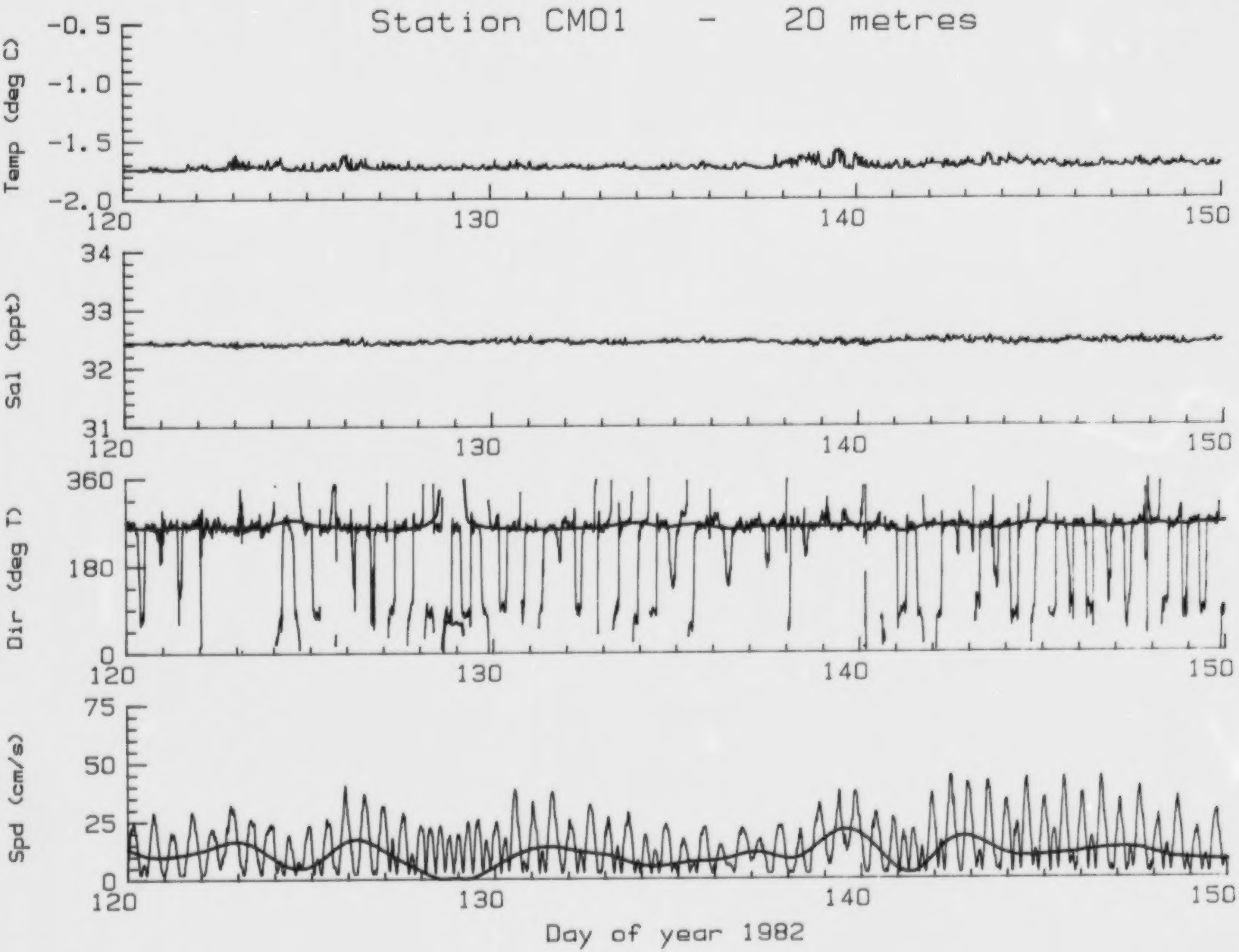
Day of year 1982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140
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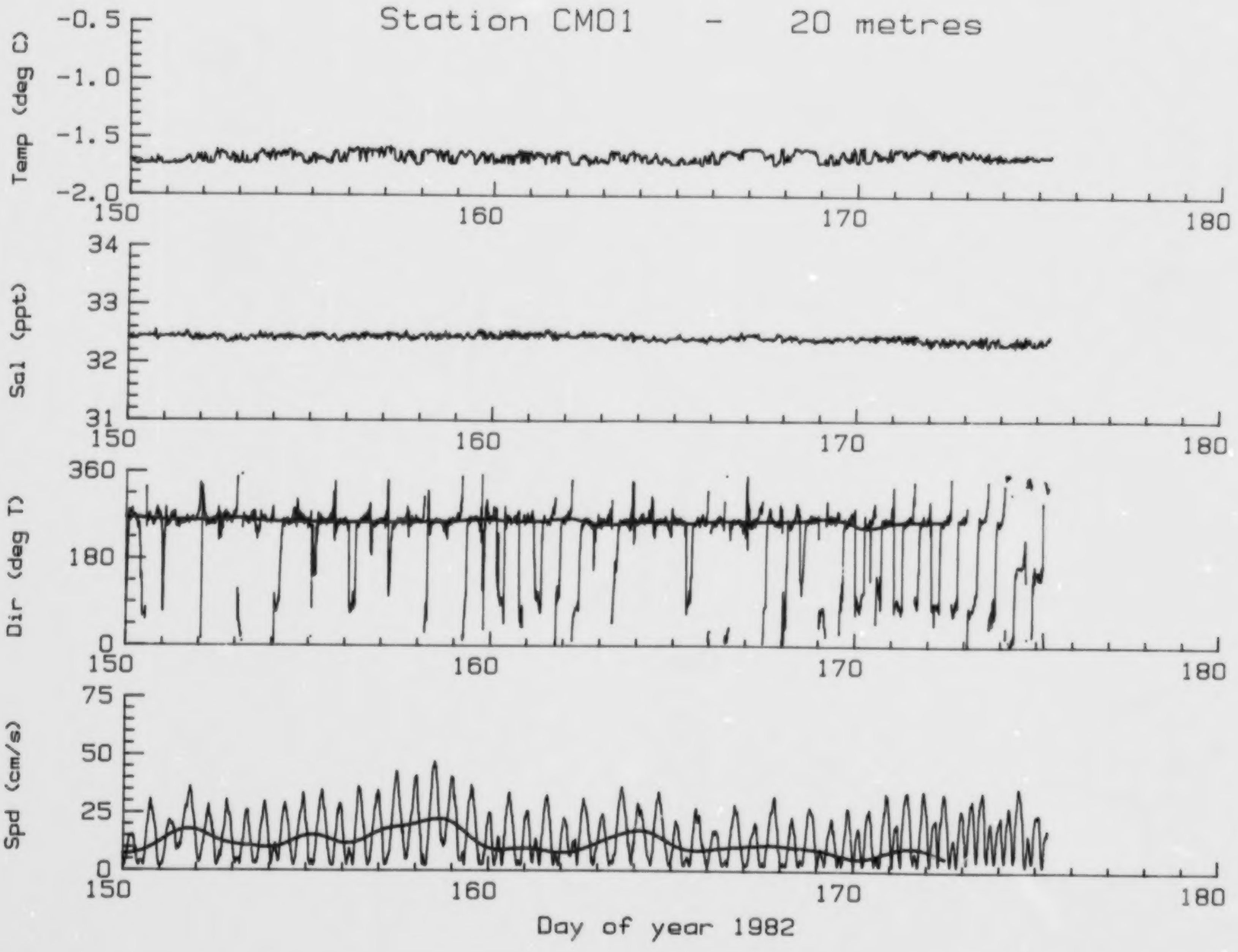
Day of year 1982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33
32
31
Dir (deg T)
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0
Spd (cm/s)
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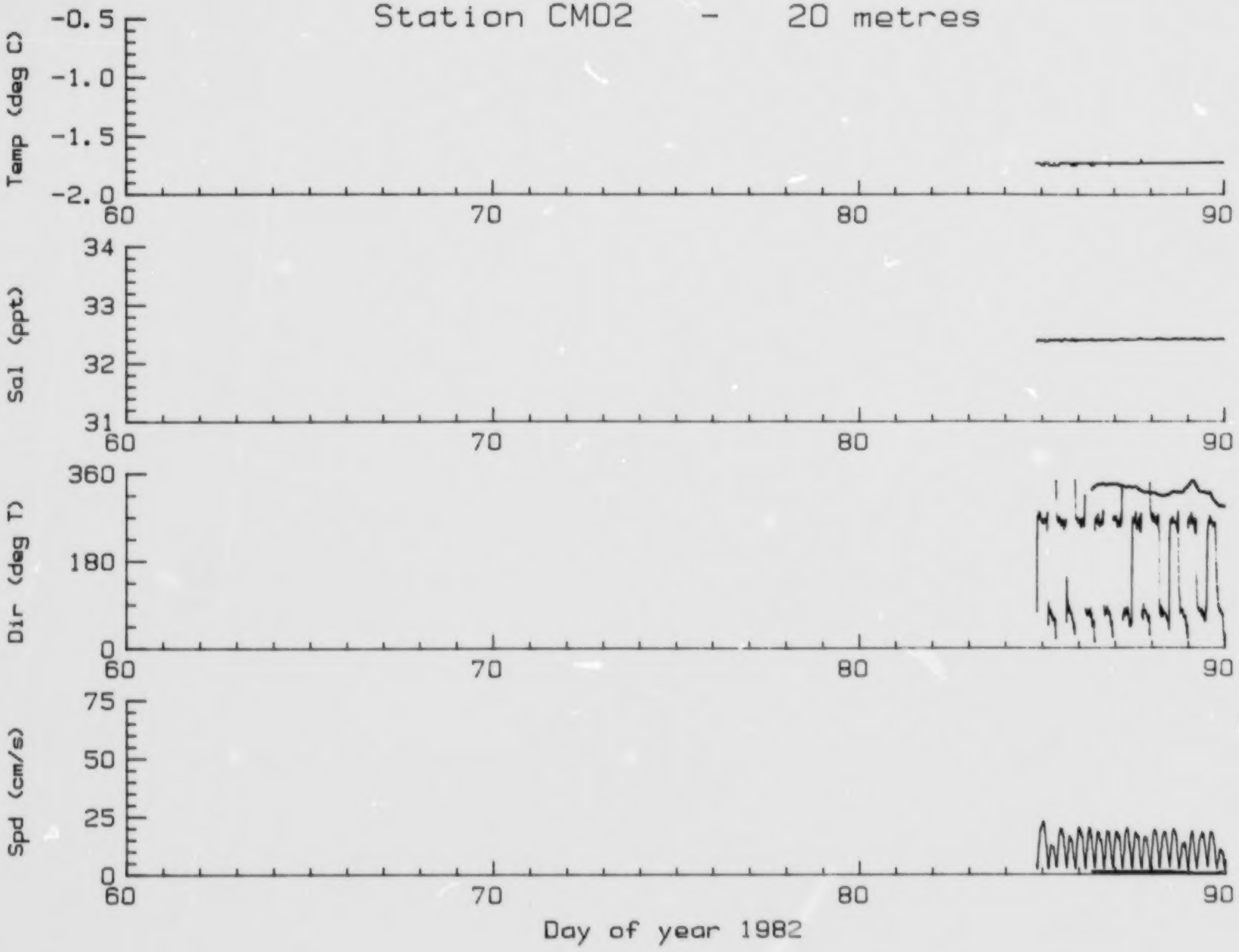
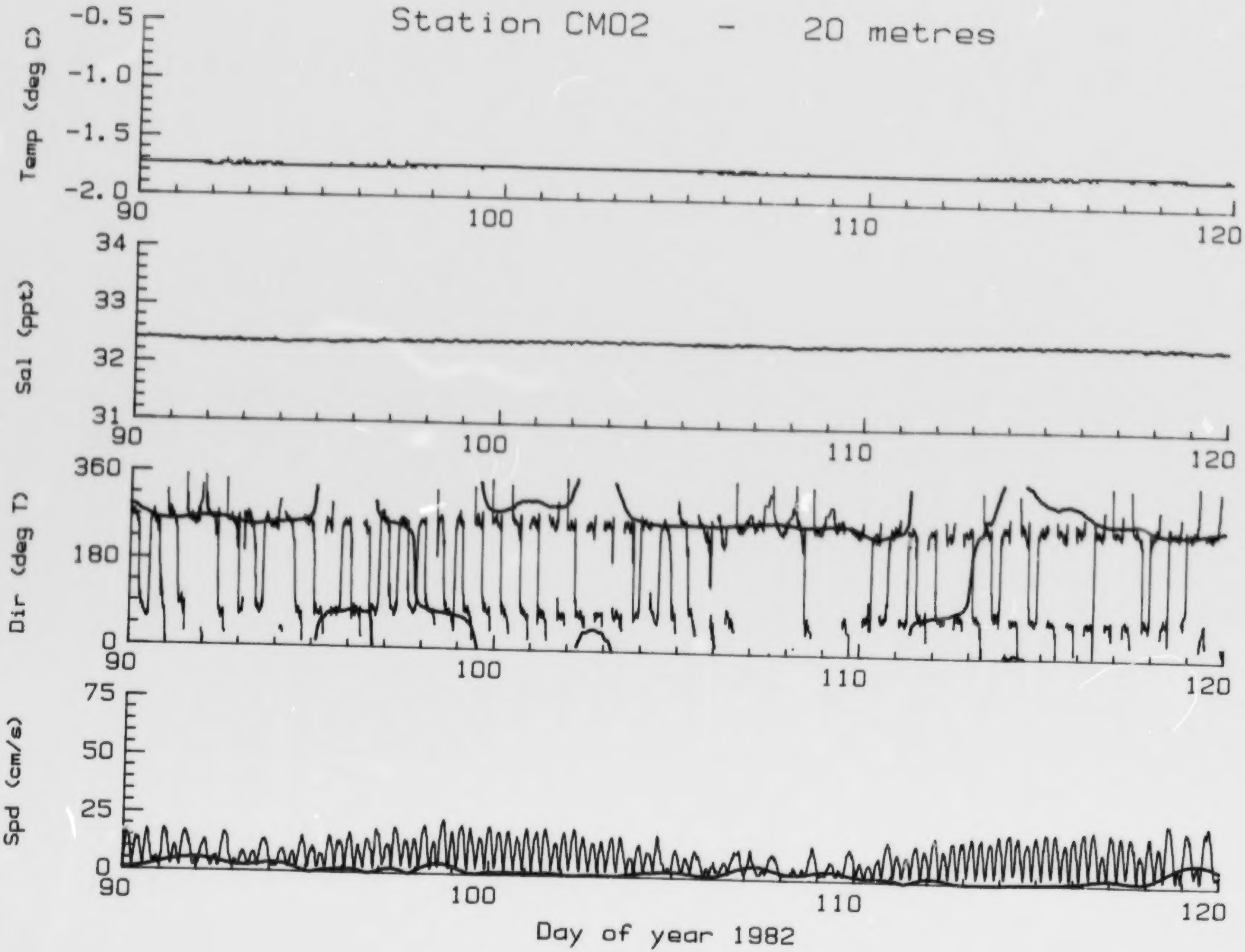
50
25
0
150
160
170
180
Day of year 1982

Station CM02 - 20 metres

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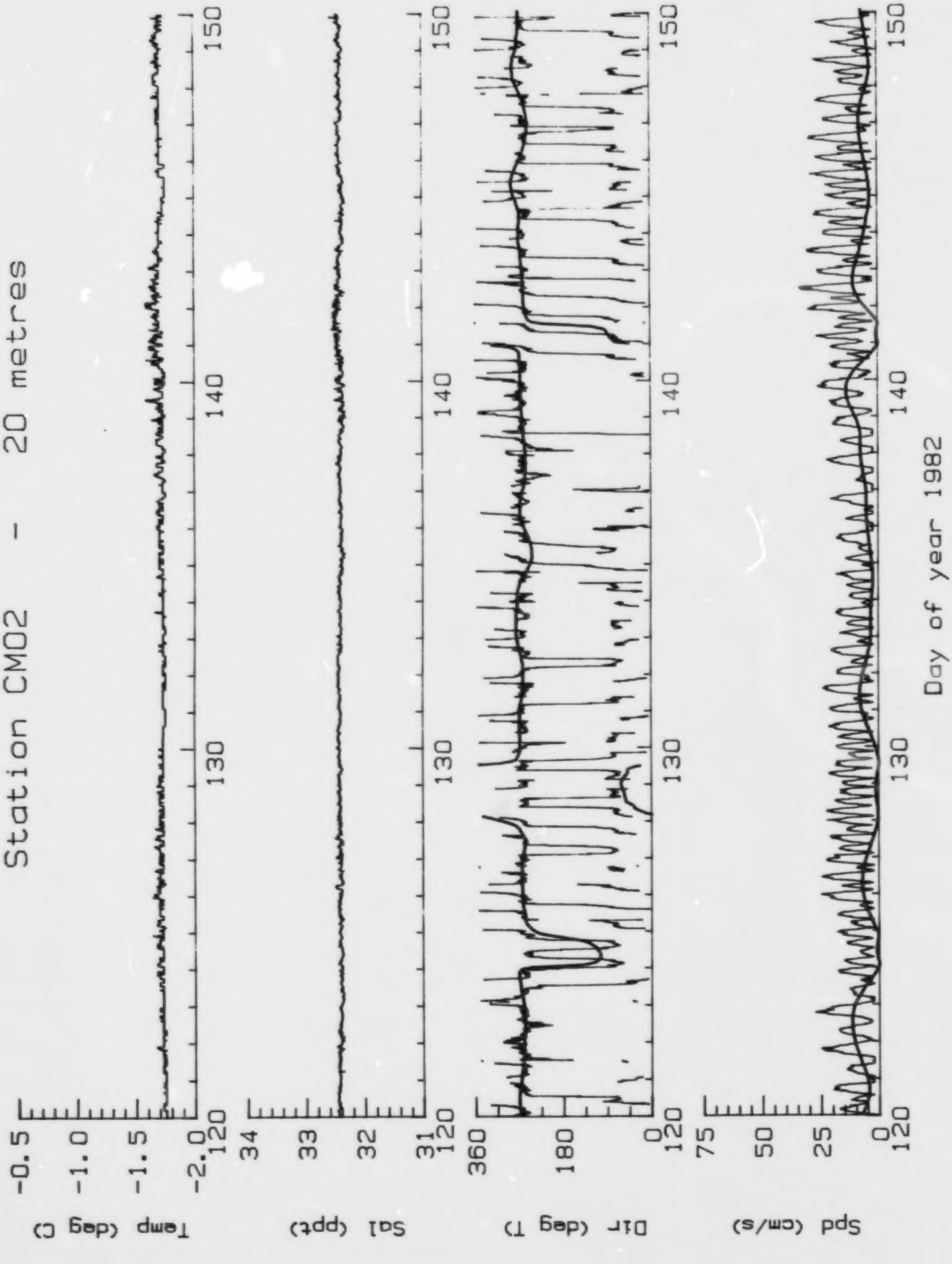
Day of year 1982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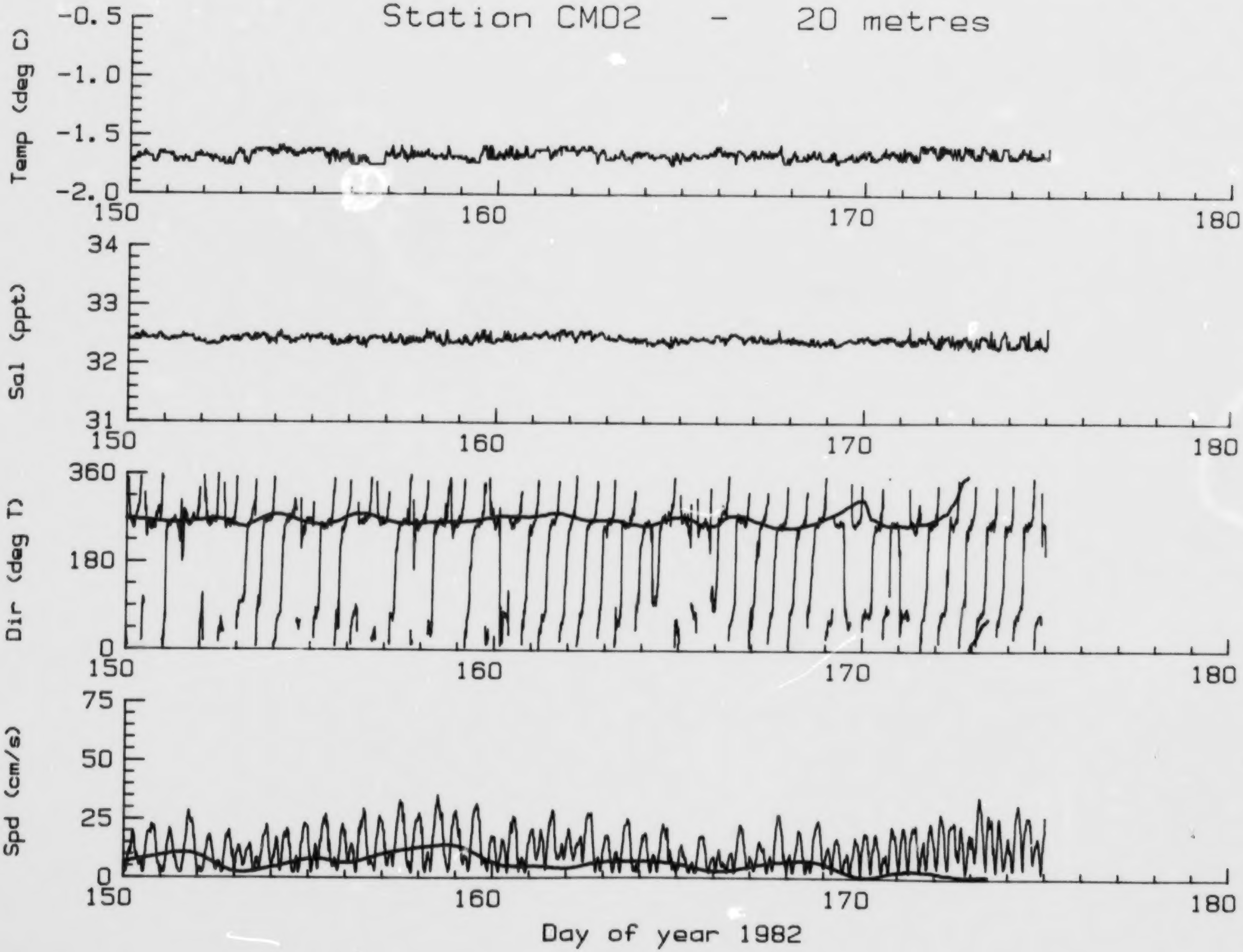
Day of year 1982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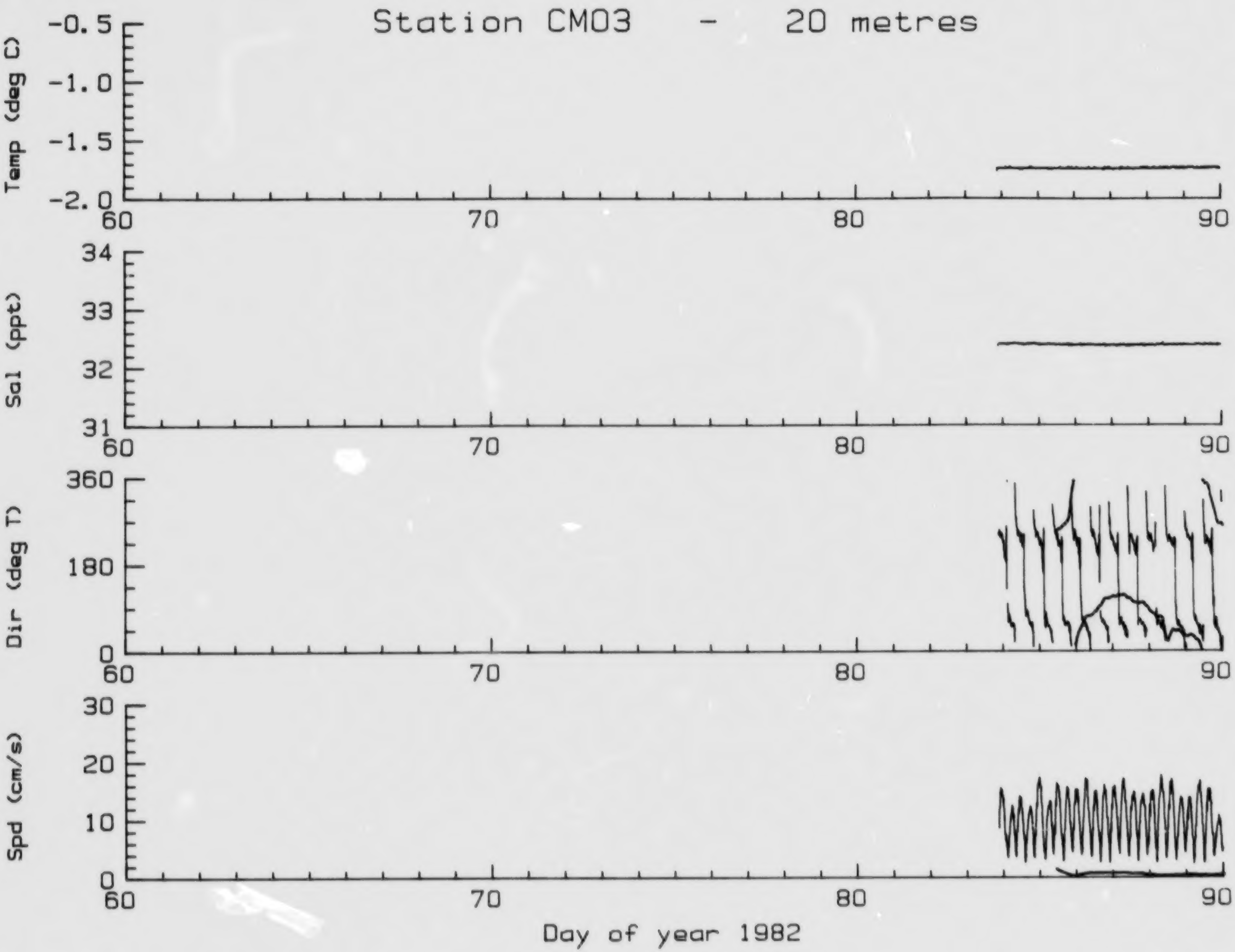
Day of year 1982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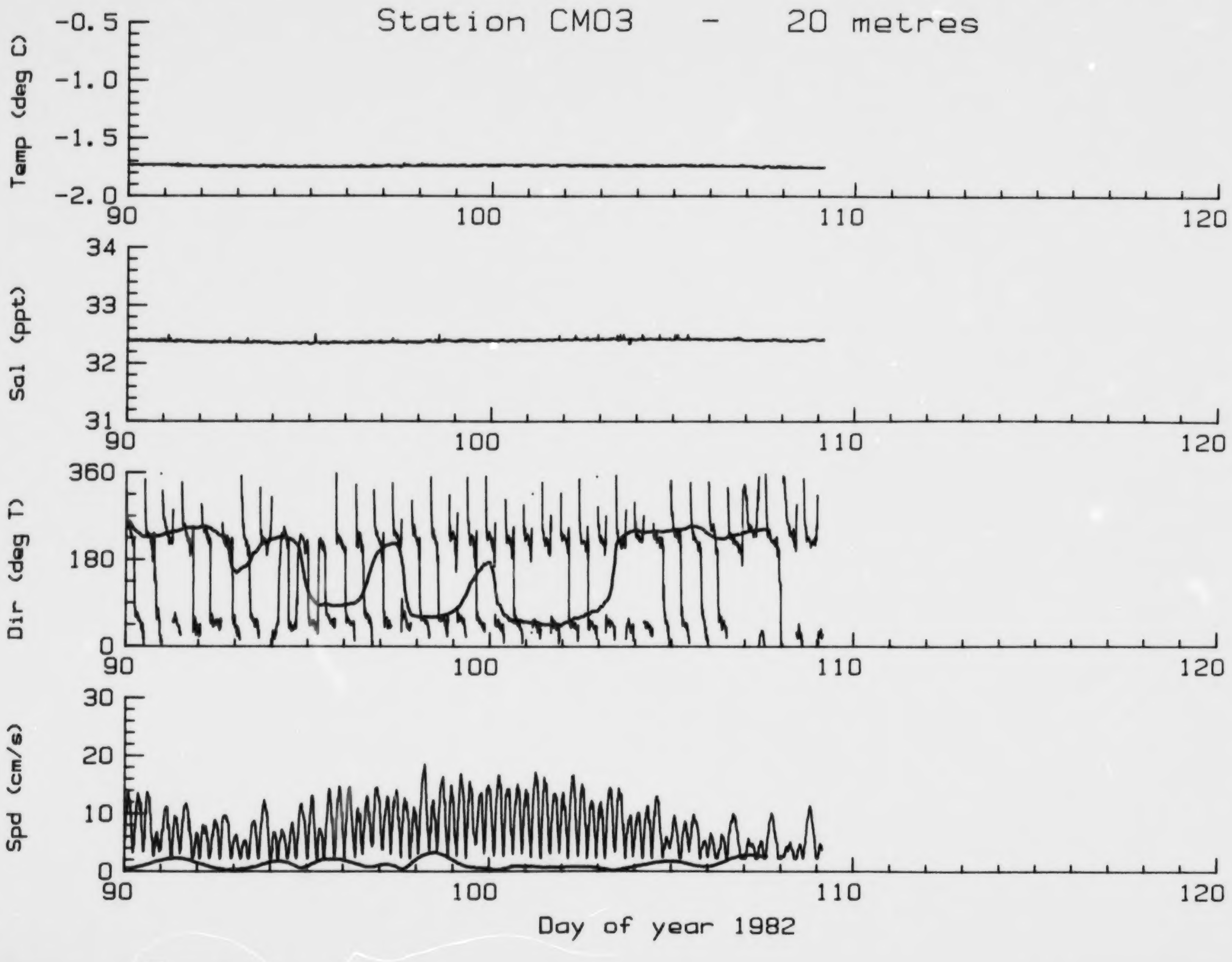
Day of year 1982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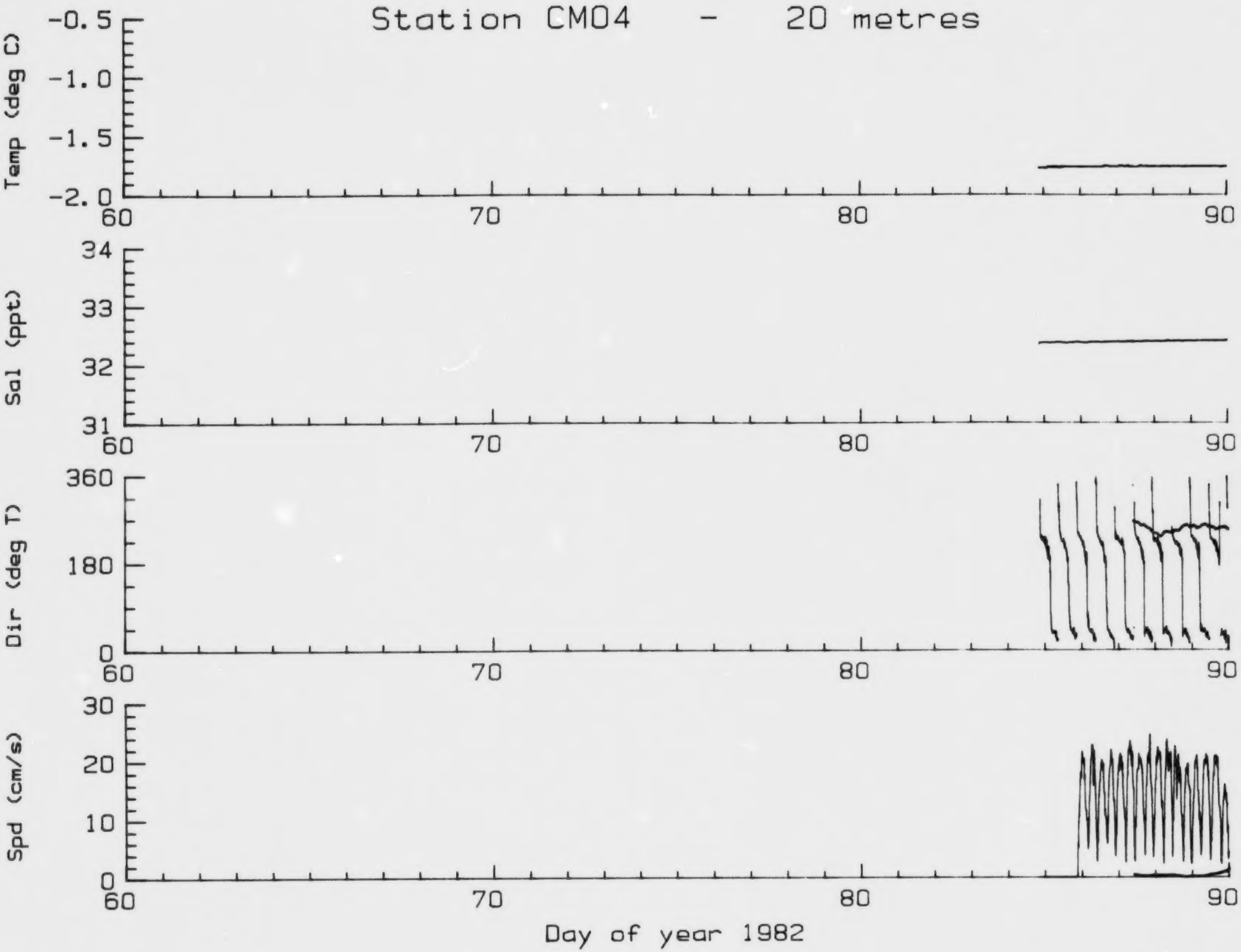
Day of year 1982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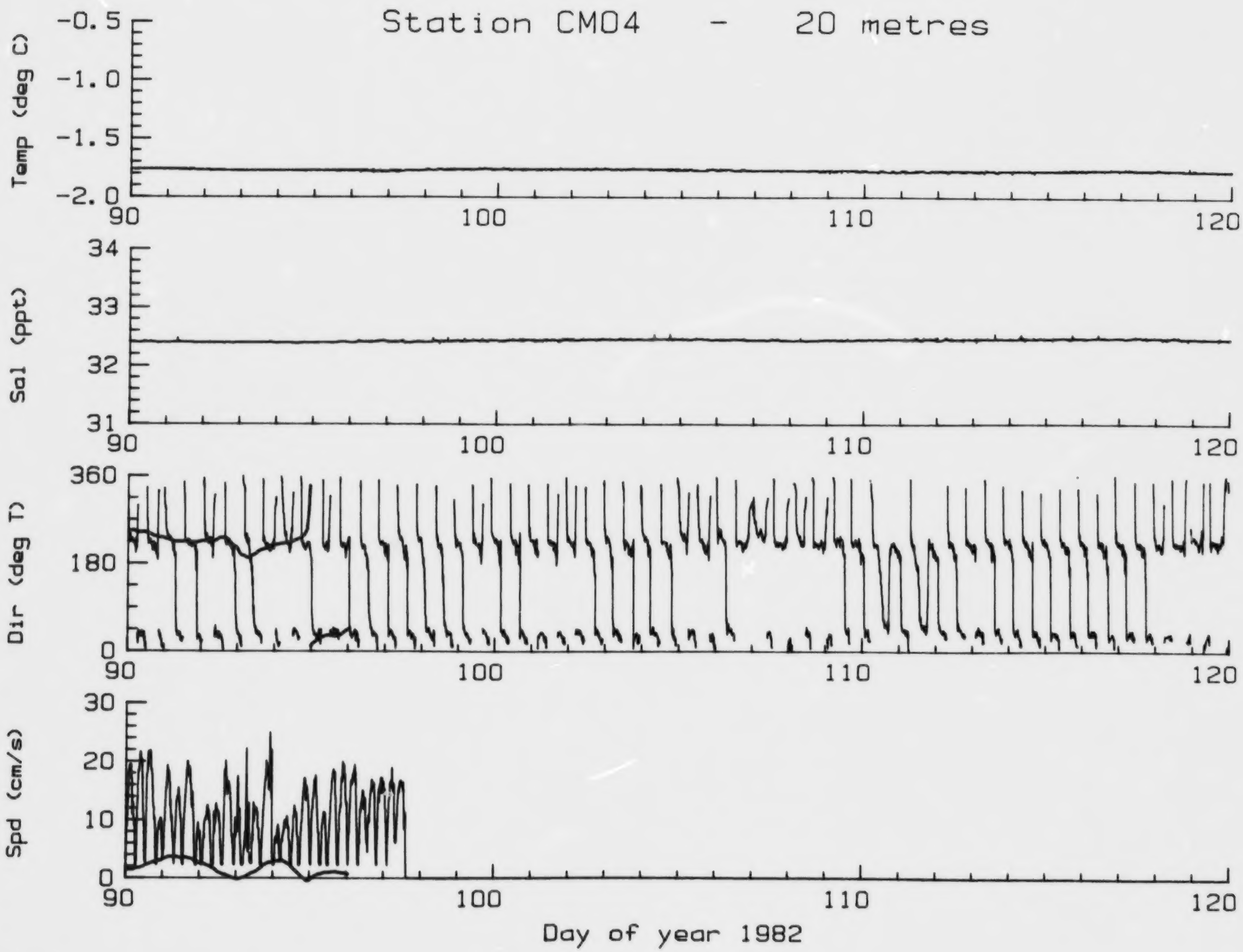
Day of year 1982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Spd (cm/s)
30
20
10
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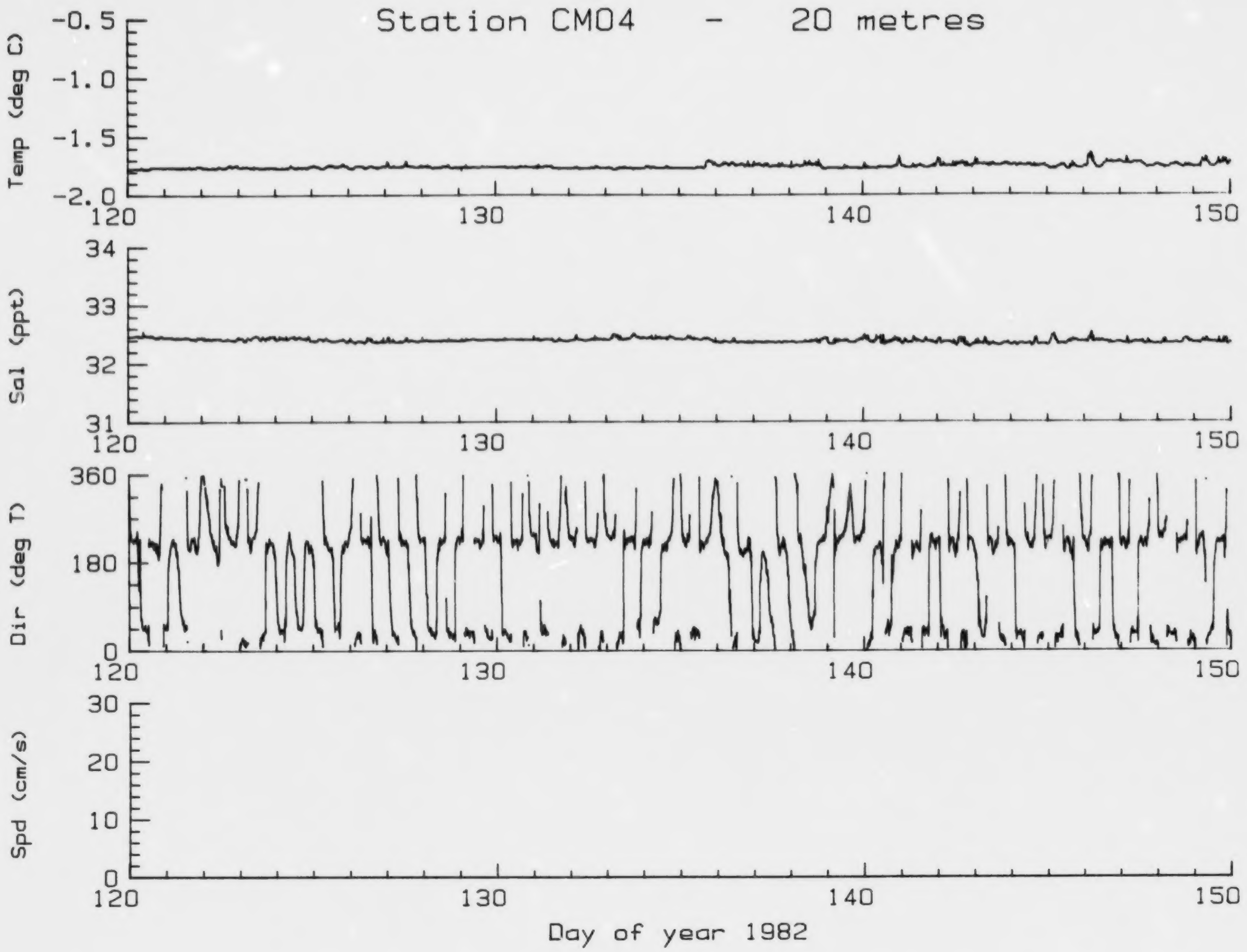
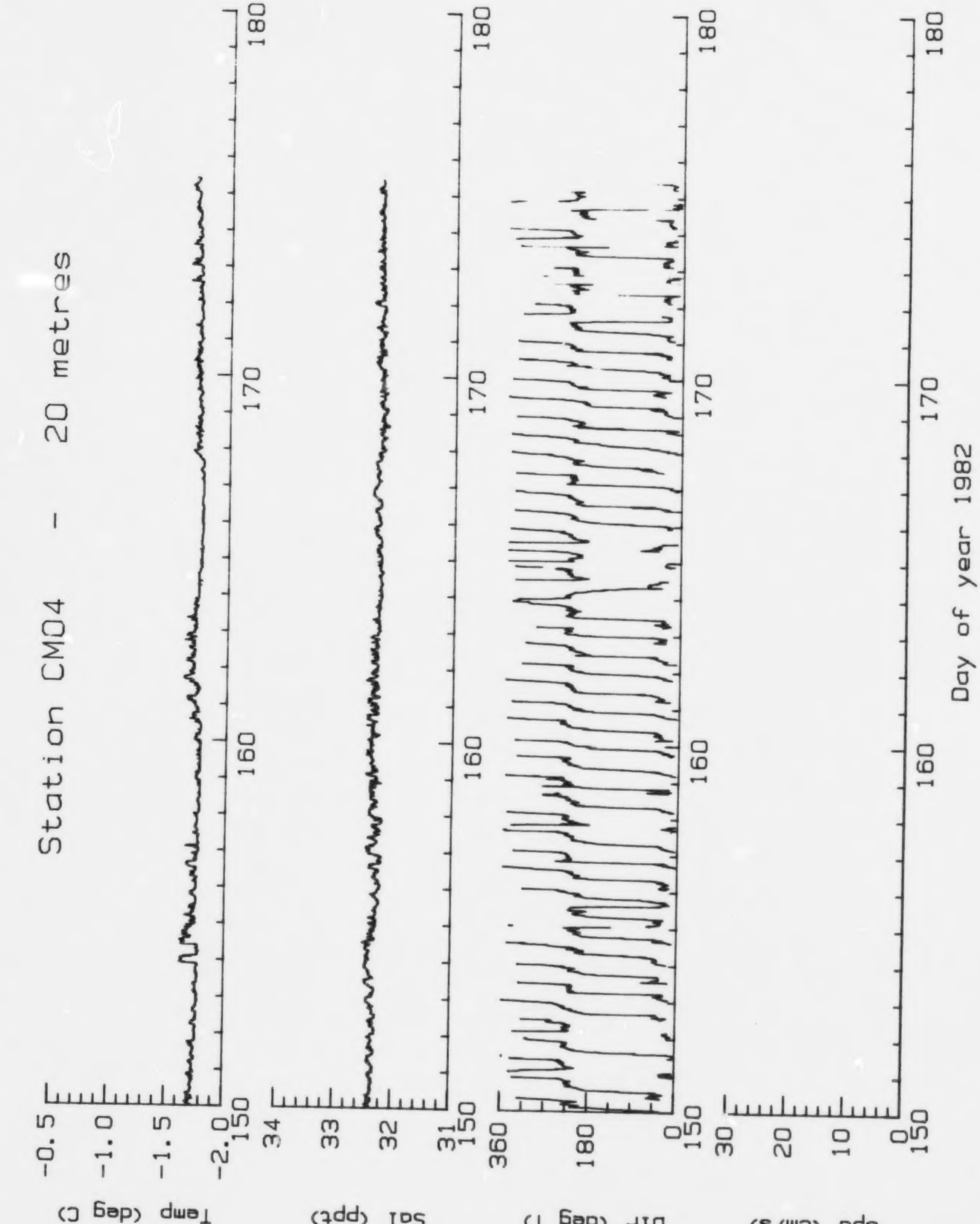
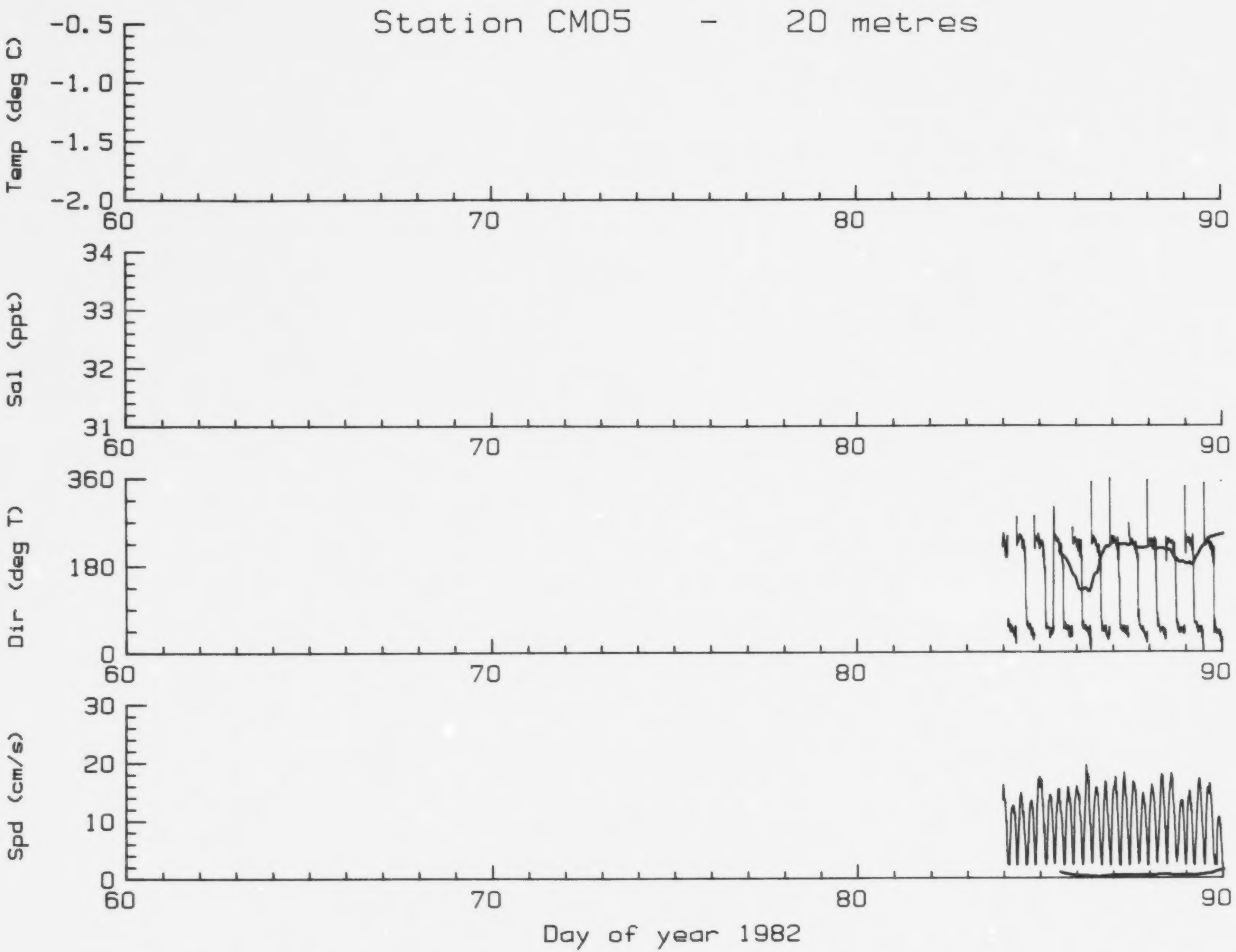
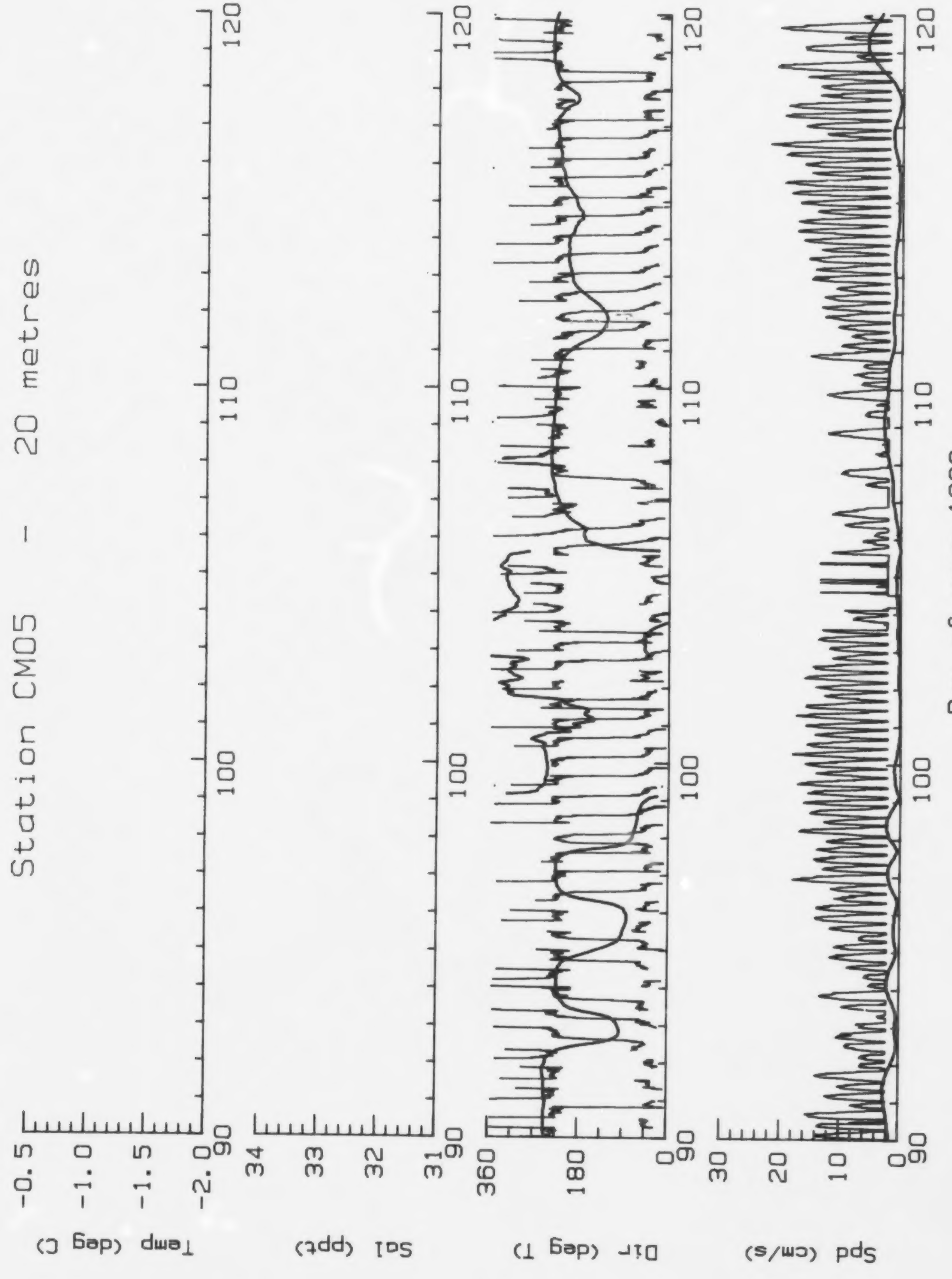
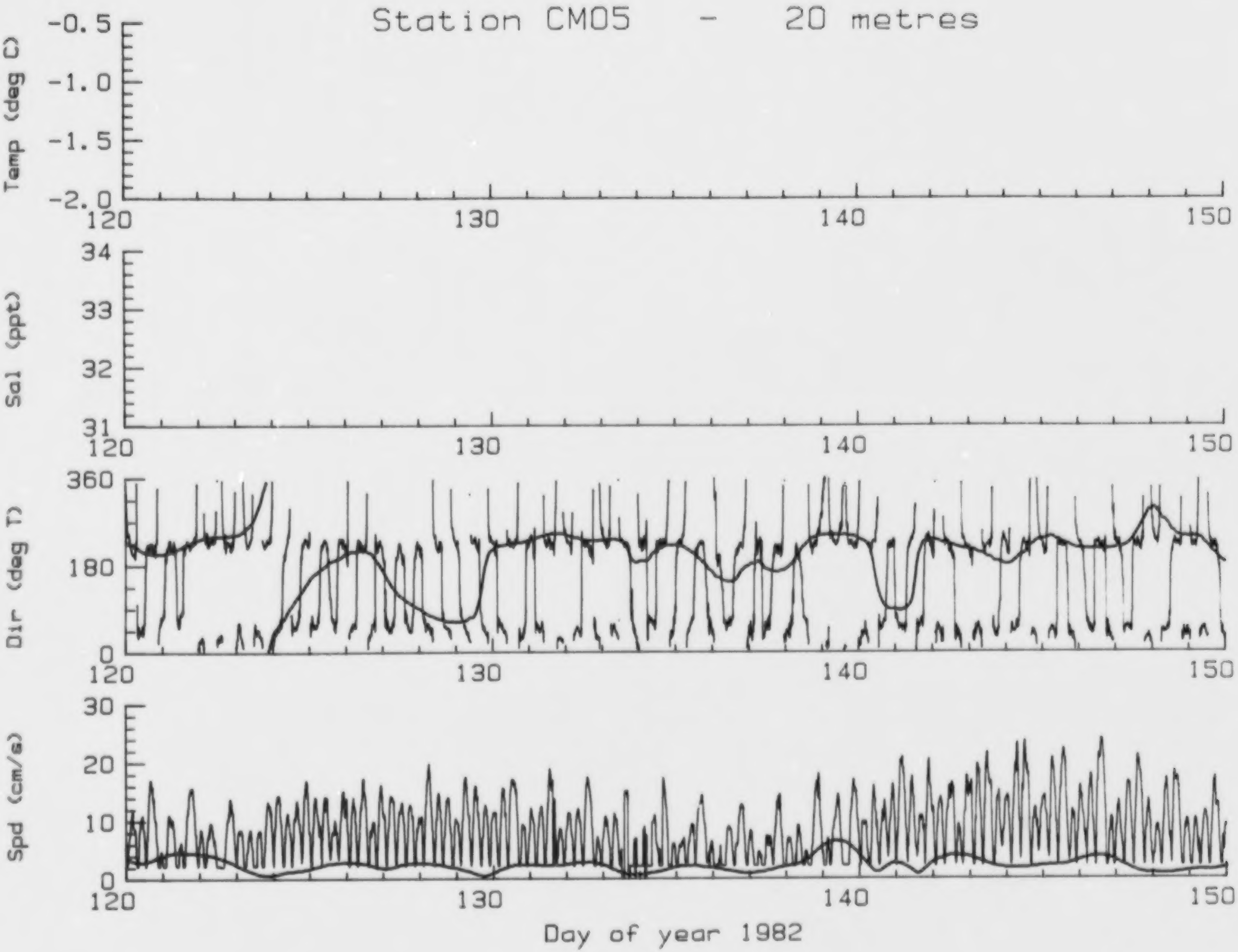
90
100
110
120
Day of year 1982

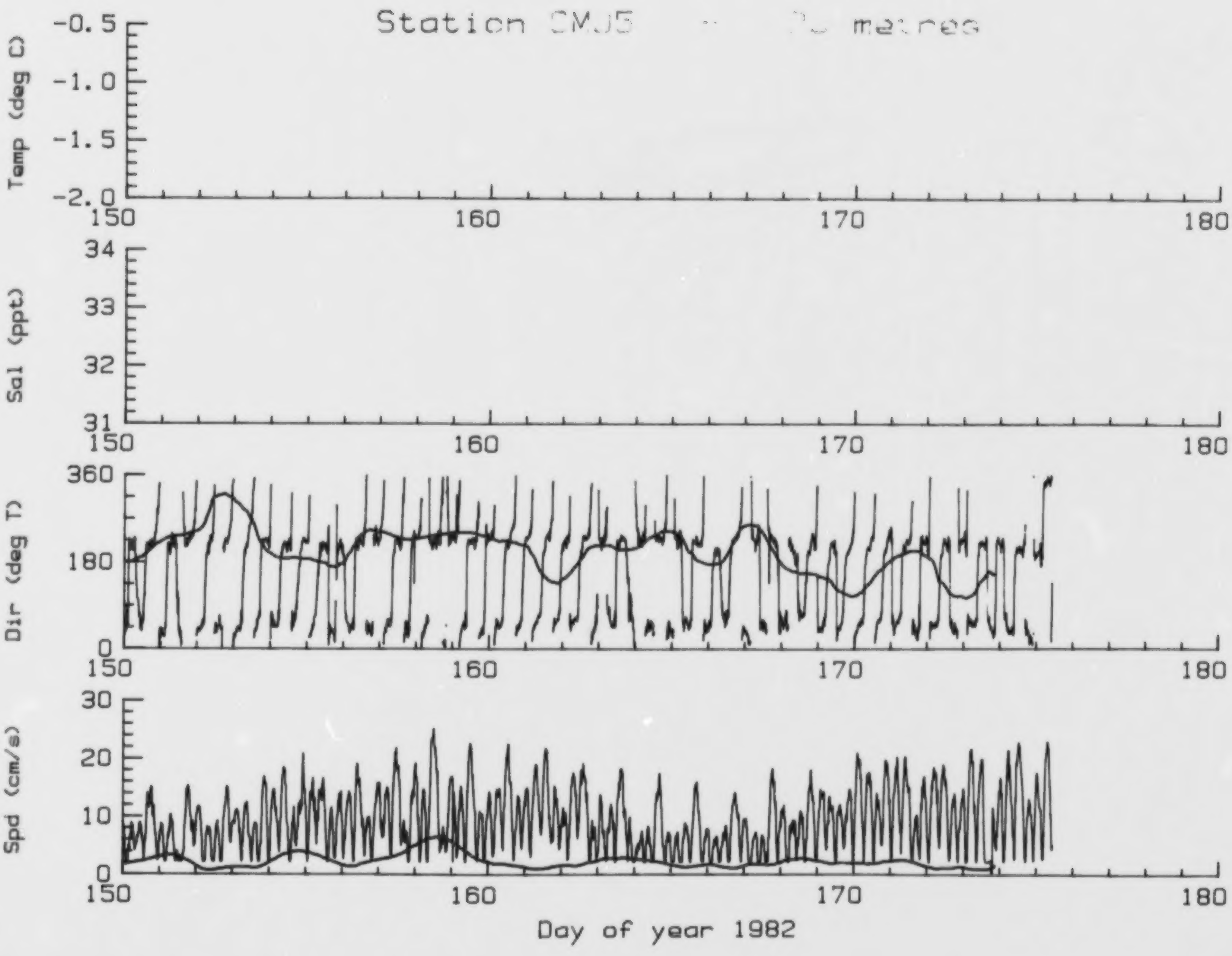

Station CM04 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

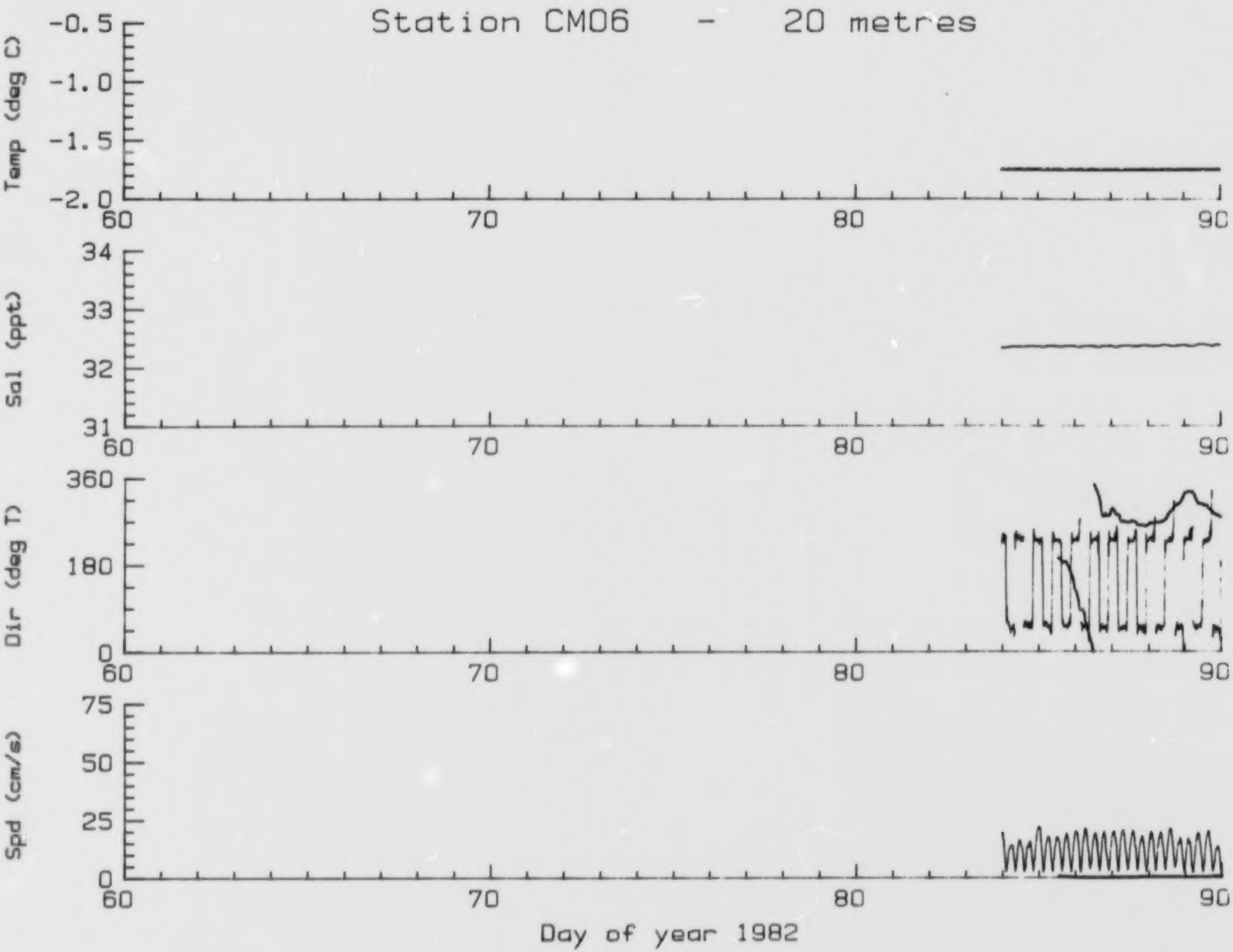

Station CM04 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

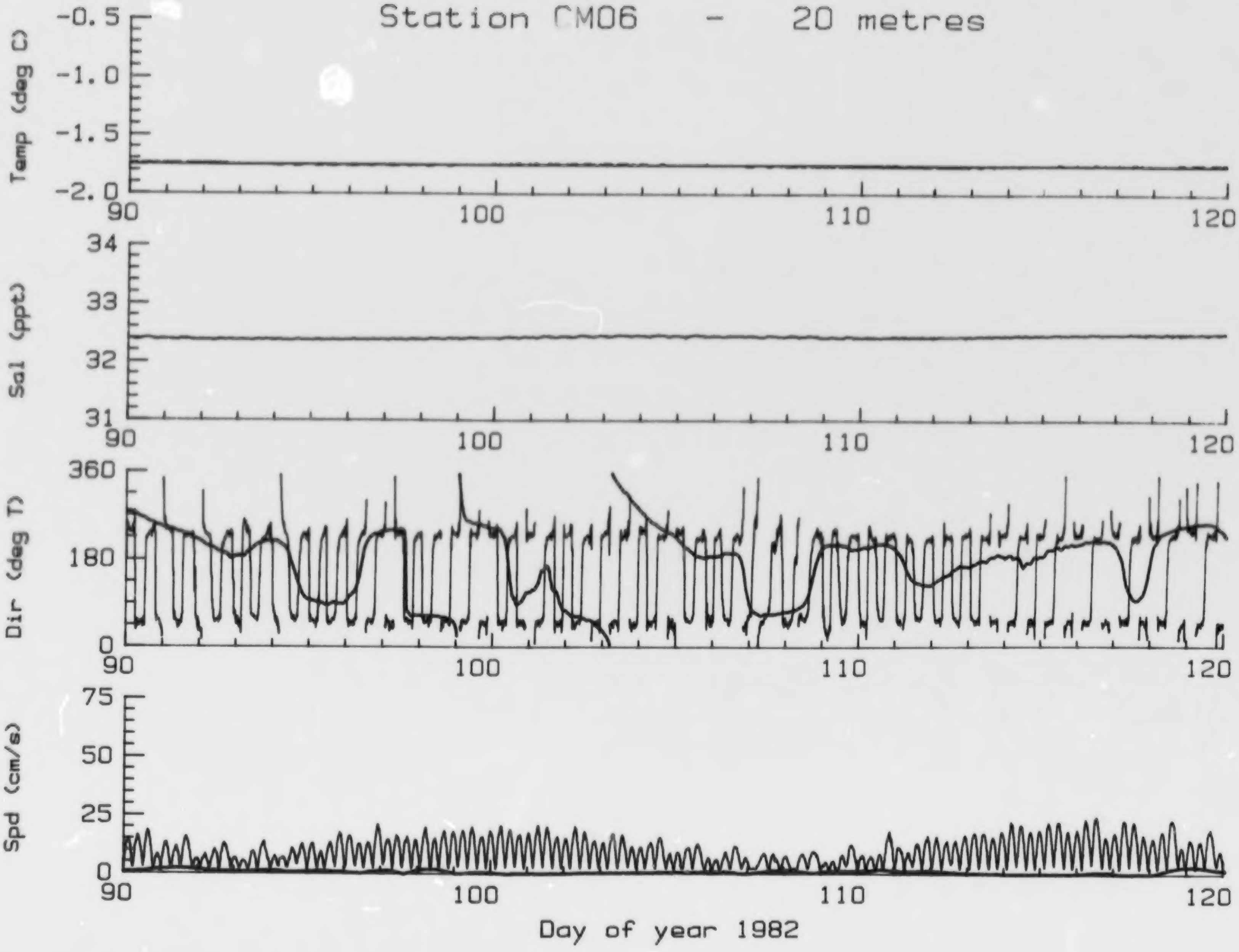

Station CM05 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
60
70
80
90
Day of year 1982

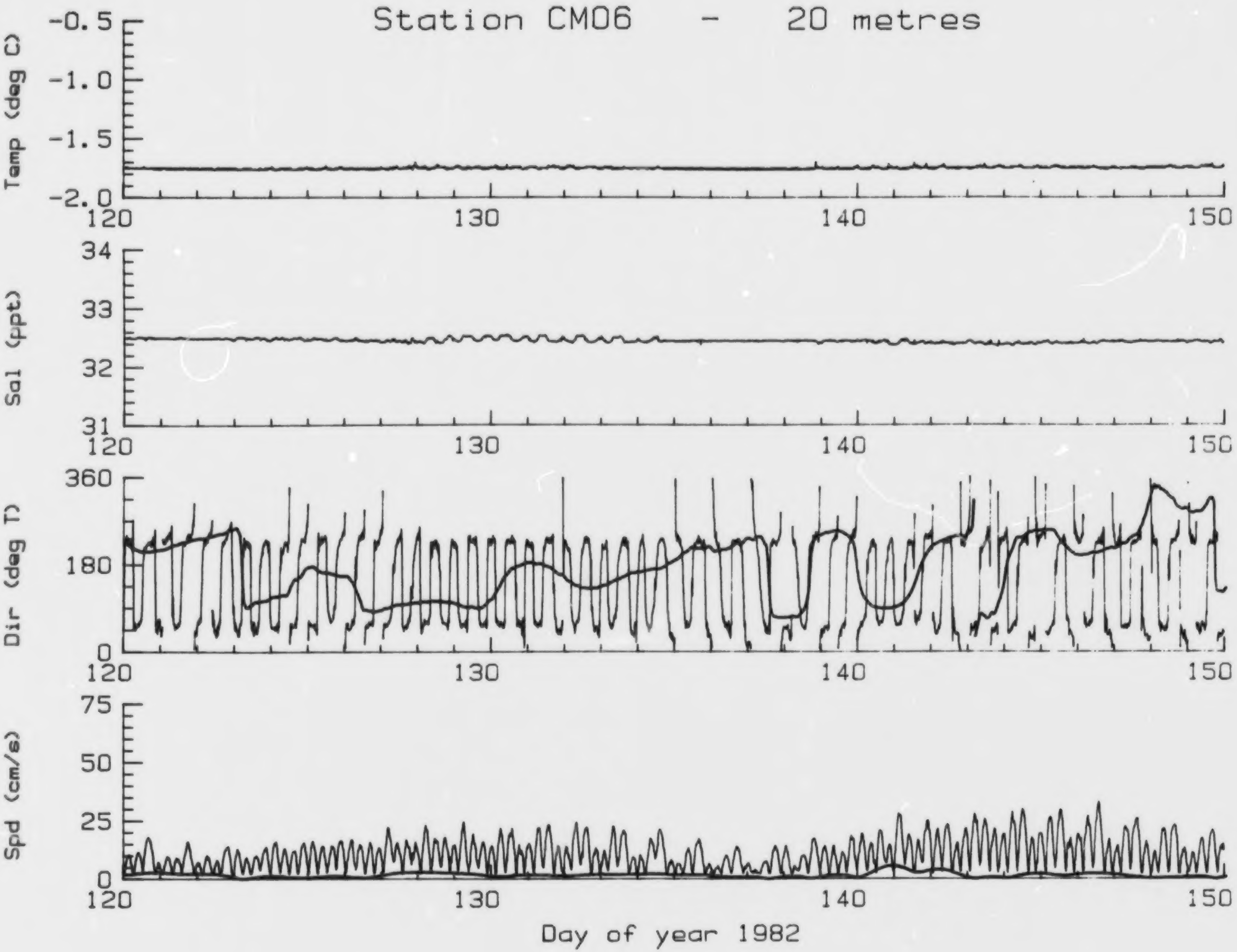

Station CM05 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

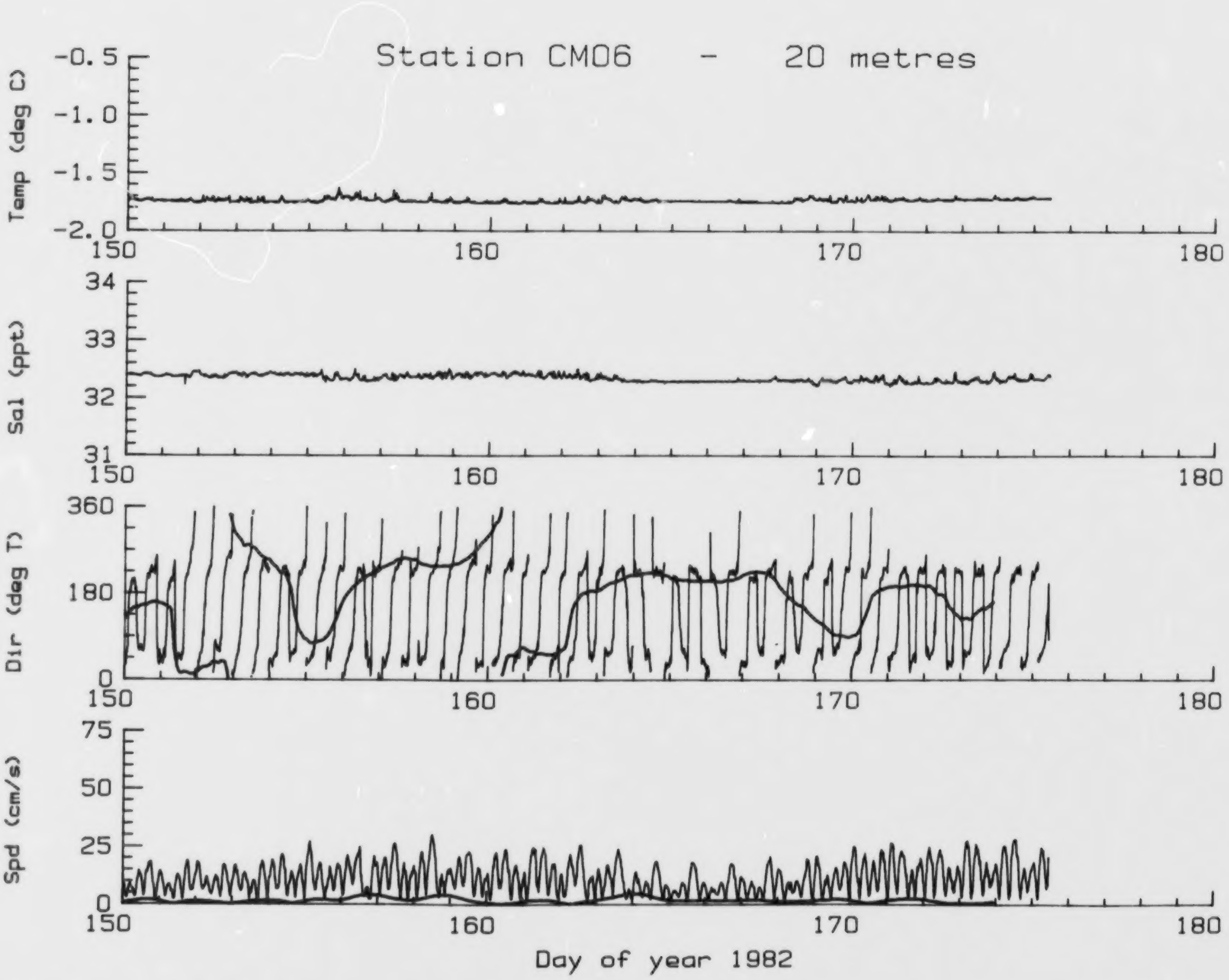

Station CM05 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

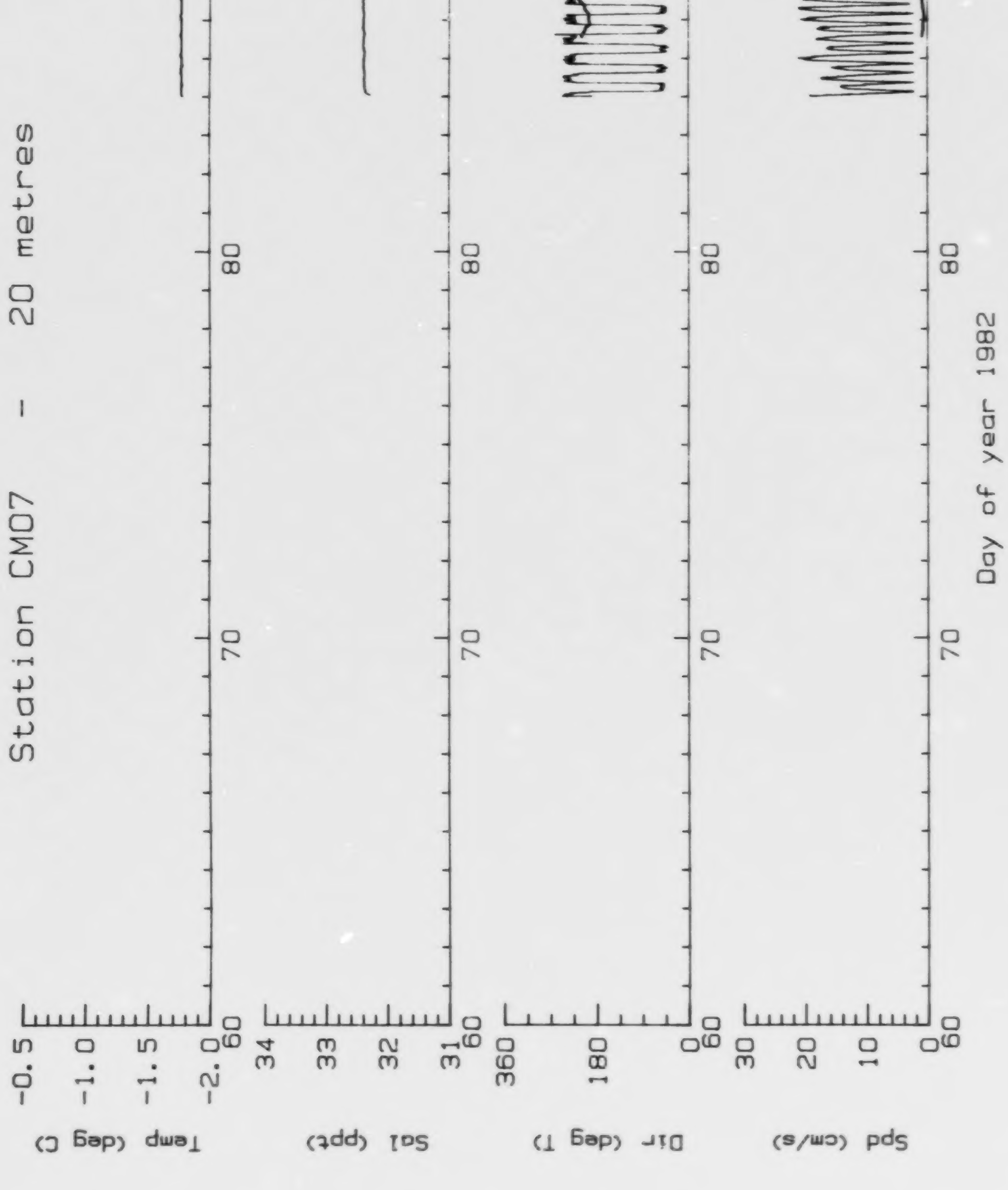

Station CMJ5
metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

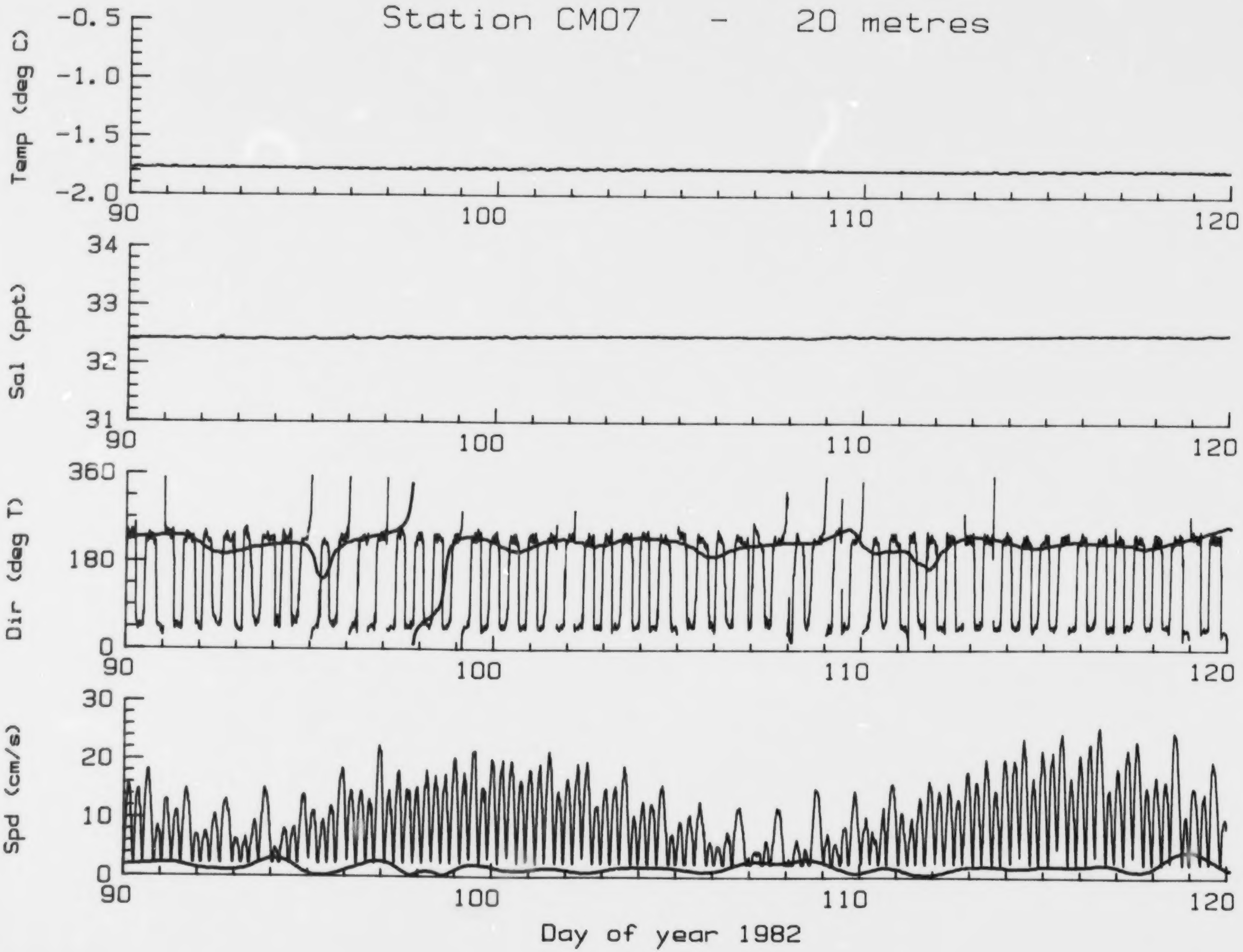

Station CM06 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
60
70
80
90
Day of year 1982

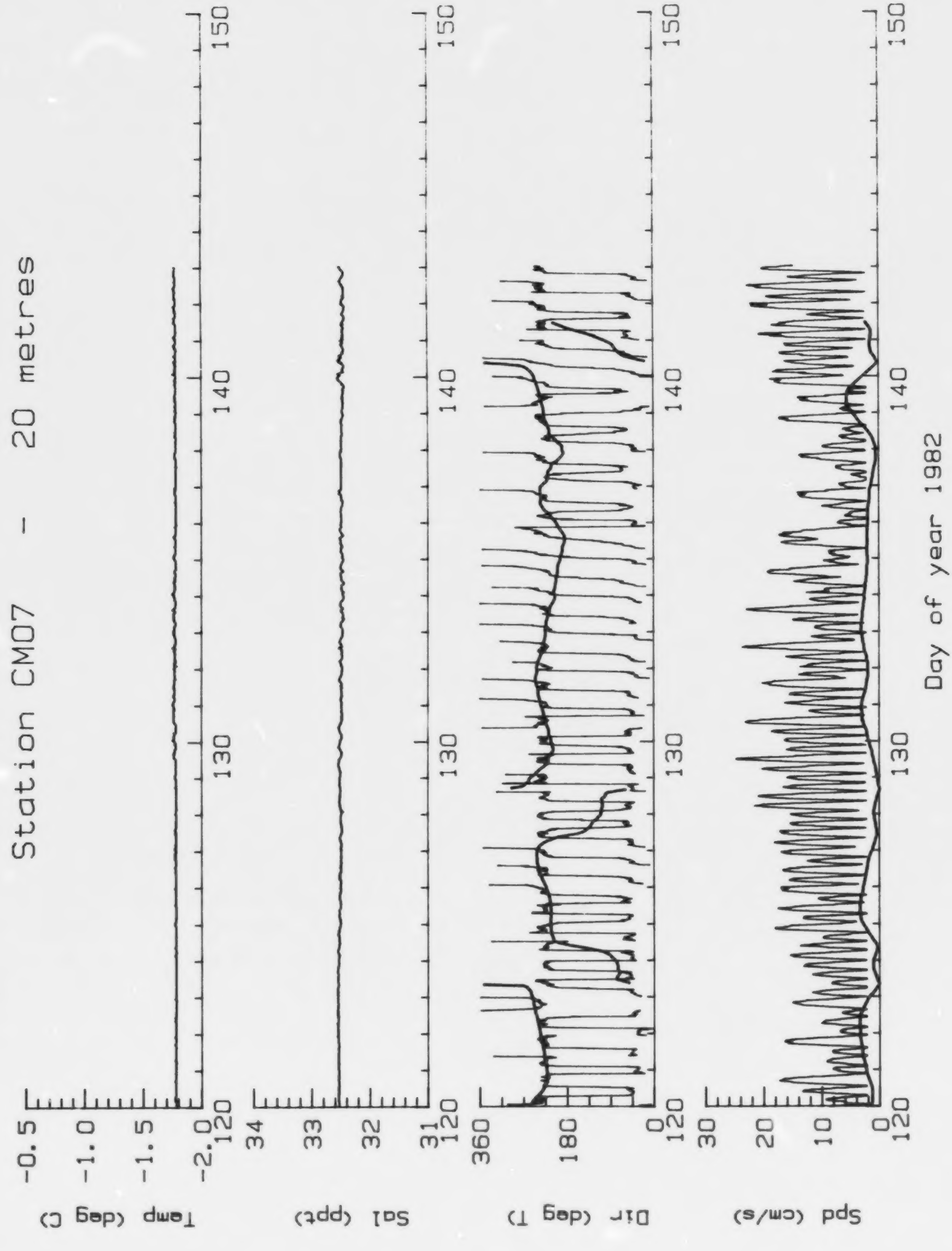

Station CM06 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1982


Station CM06 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1982

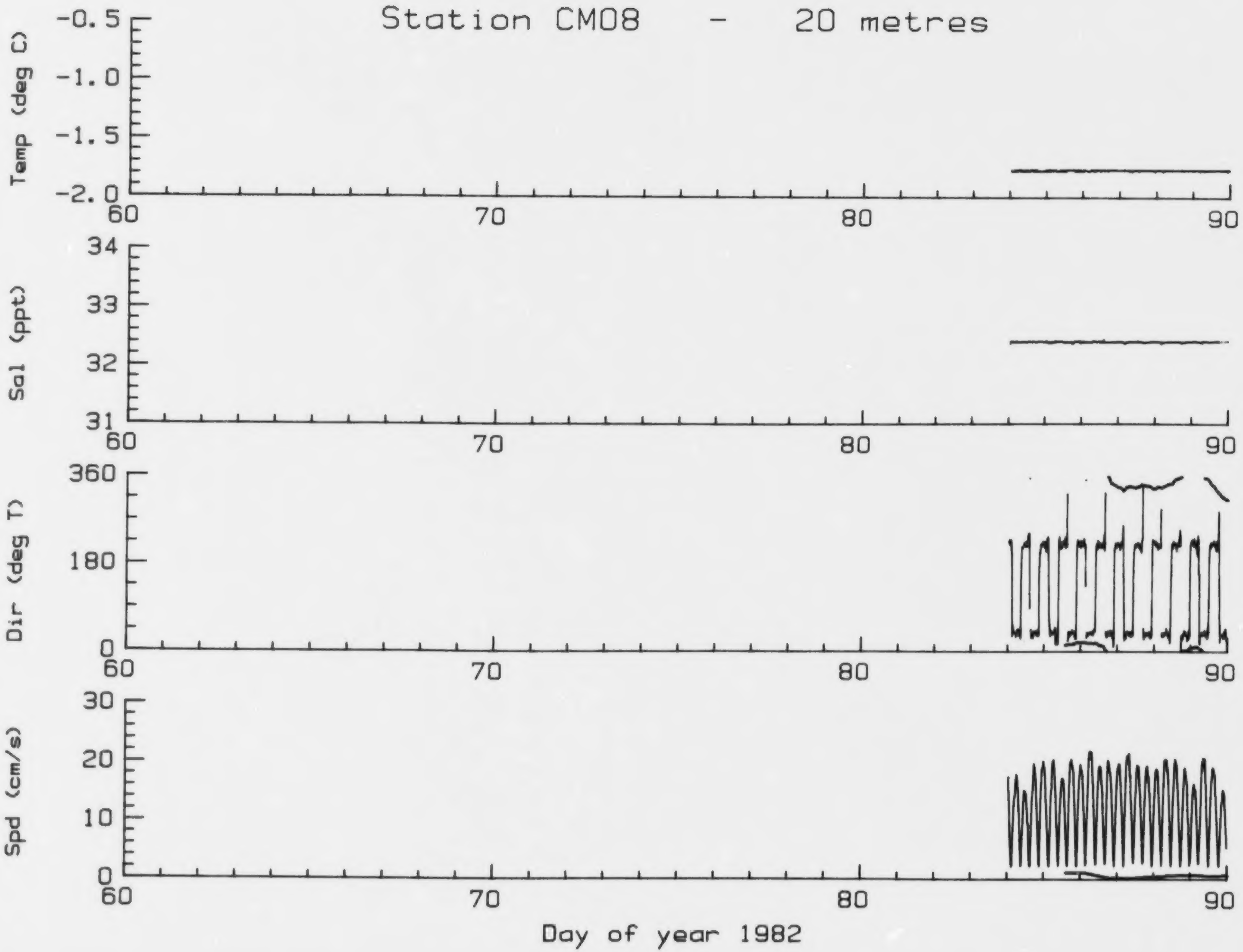

Station CM06 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1982

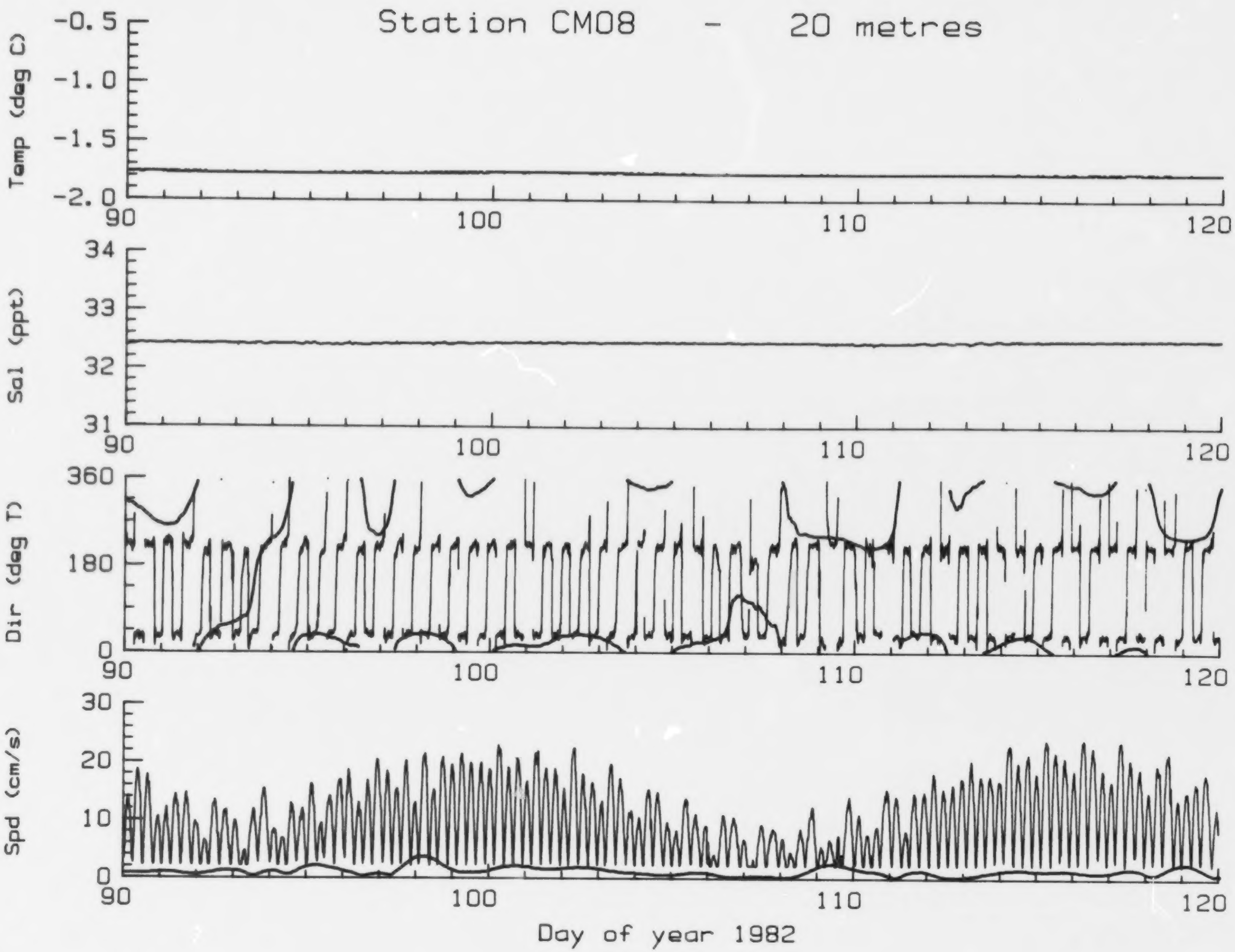

Station CM07 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
60
70
80
90
Day of year 1982

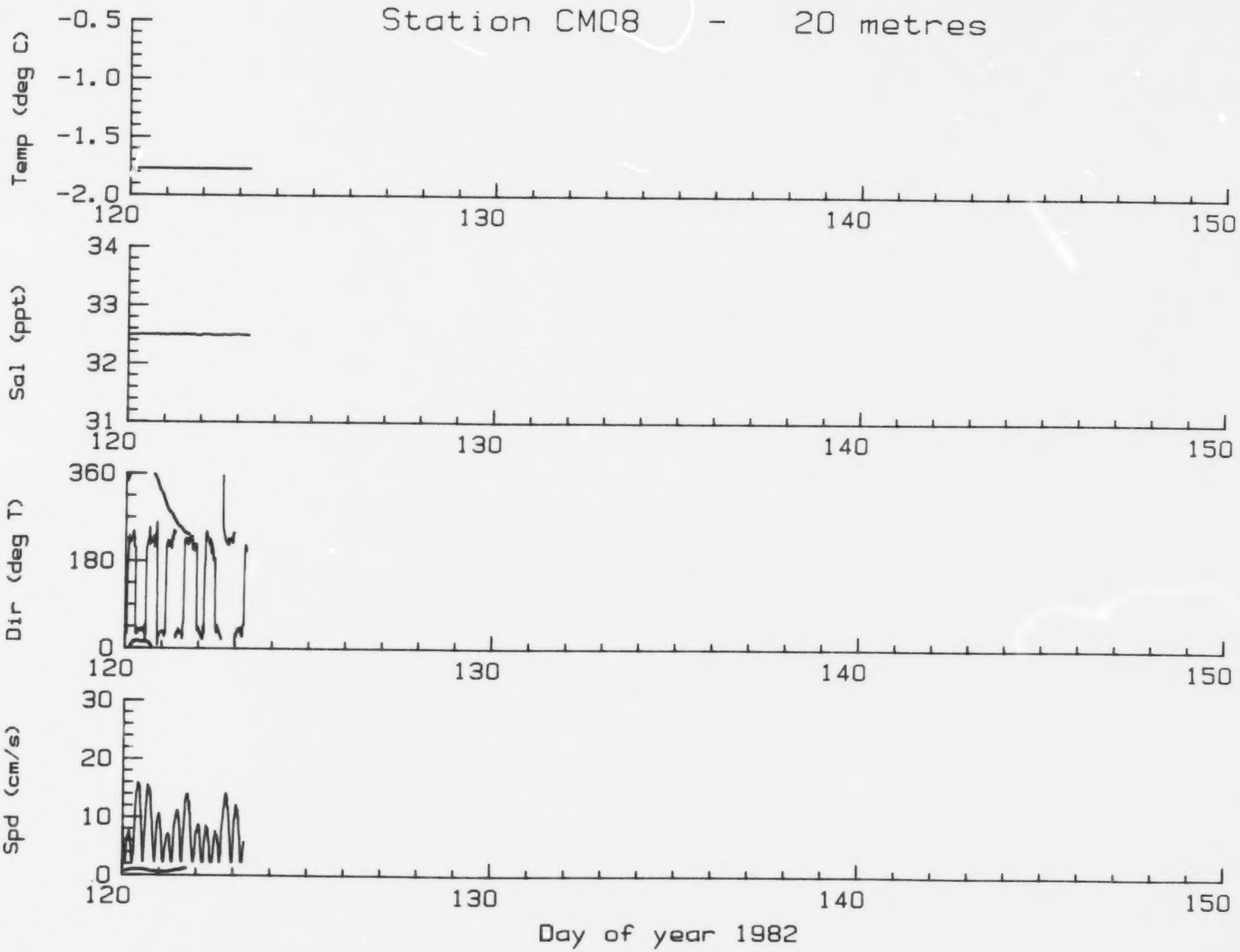

Station CM07 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

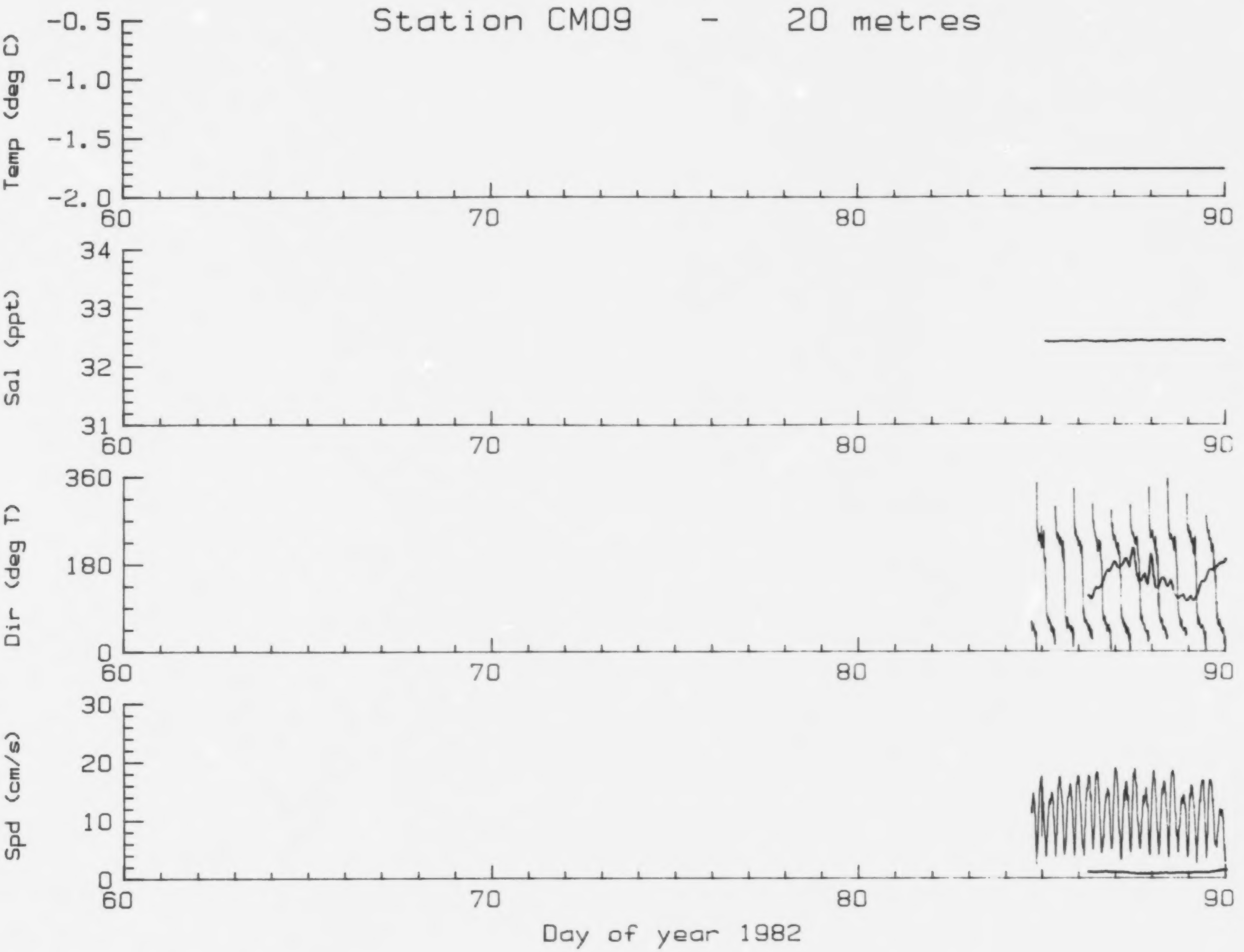


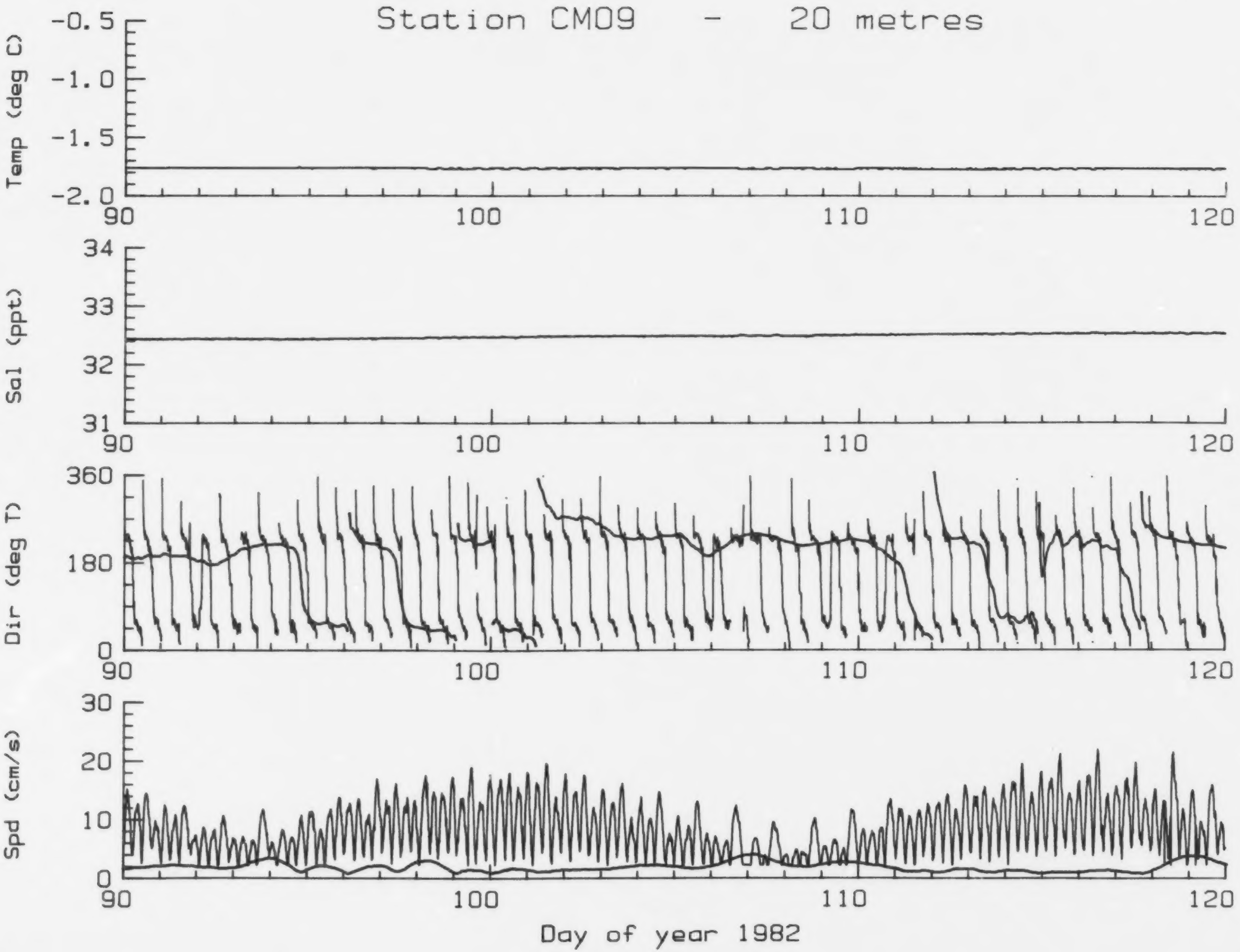
Station CM07 - 20 metres


Station CM08 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
60
70
80
90
Day of year 1982

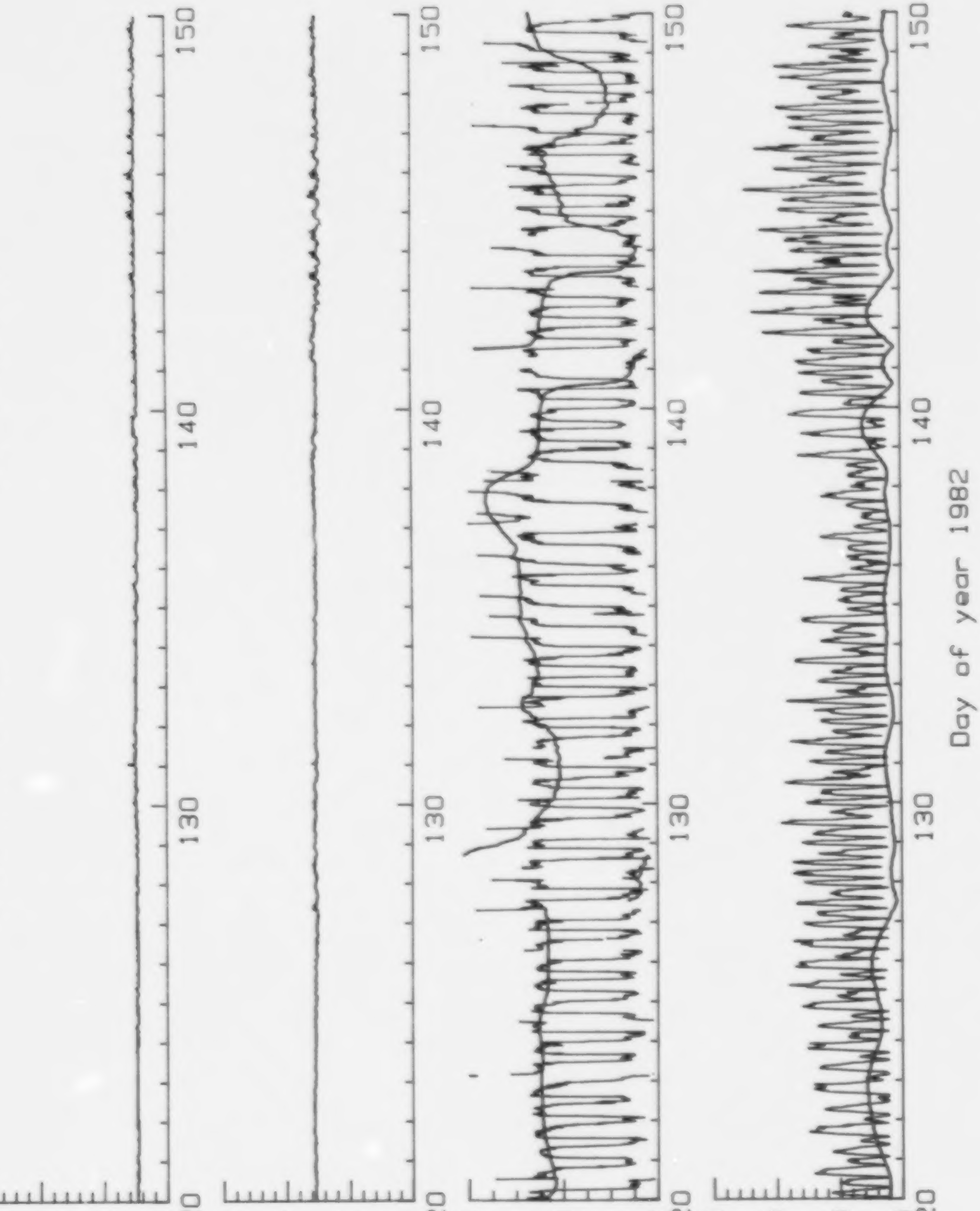

Station CM08 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

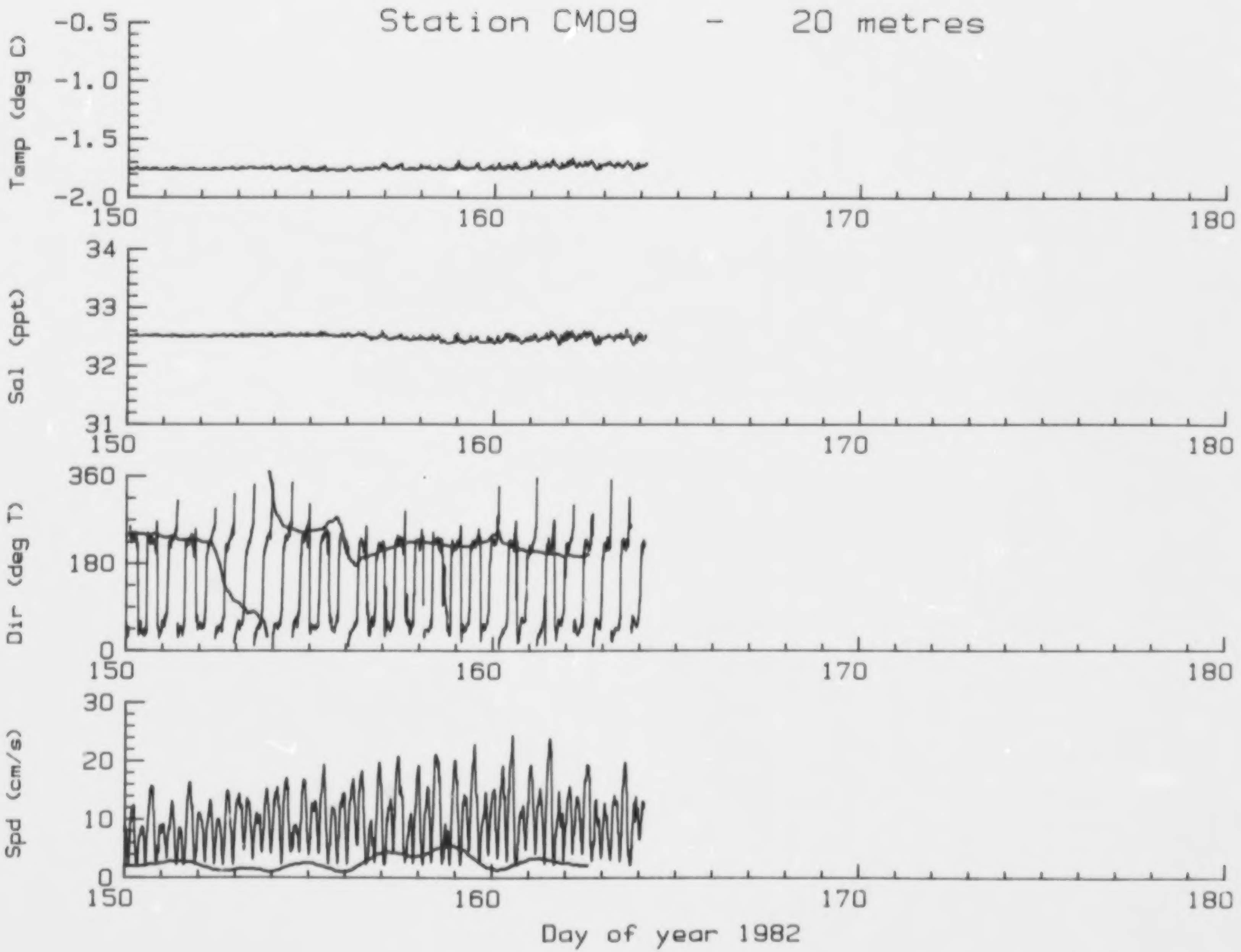

Station CM08 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

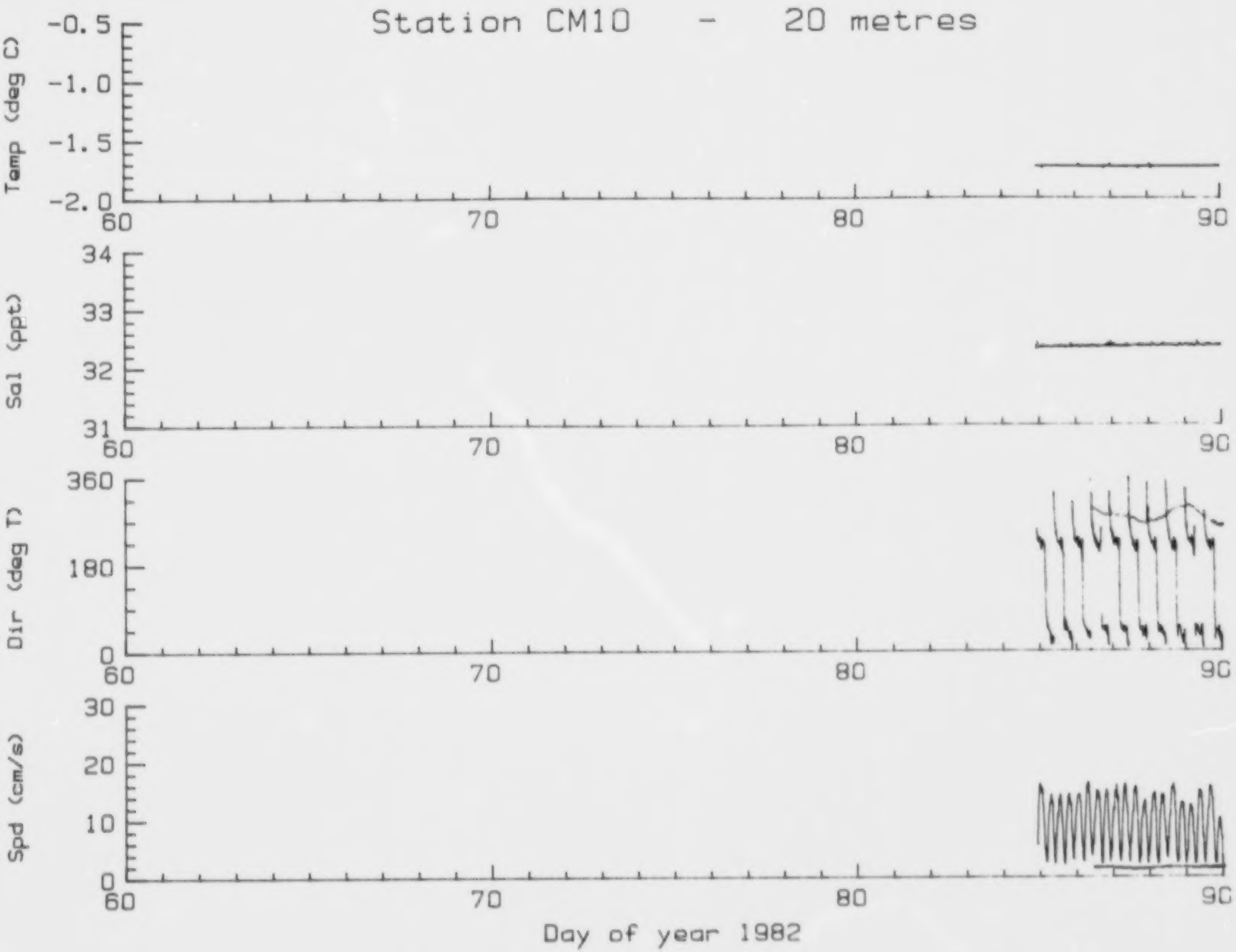

Station CM09 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
60
70
80
90
Day of year 1982


Station CM09 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

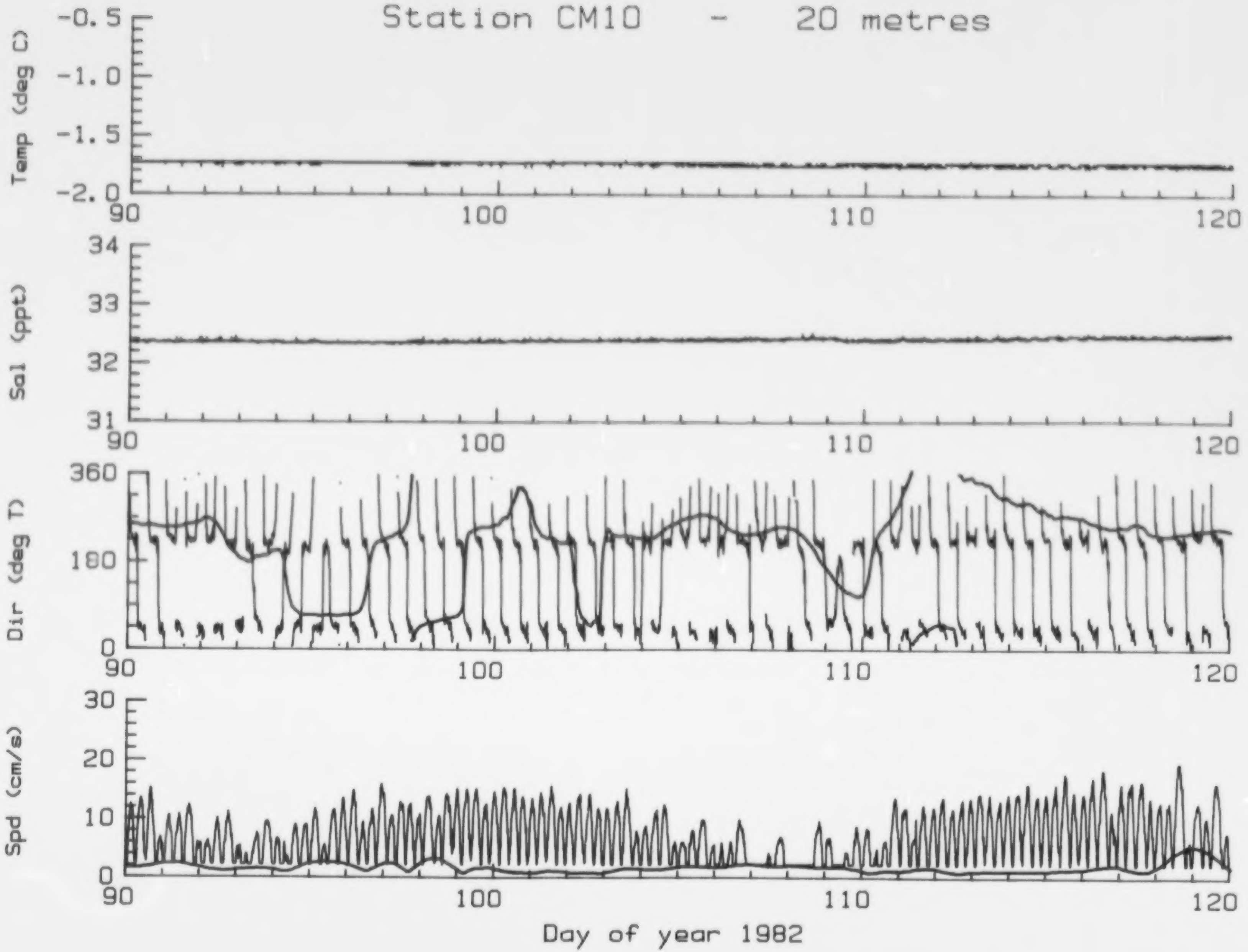
Station CM09 - 20 metres

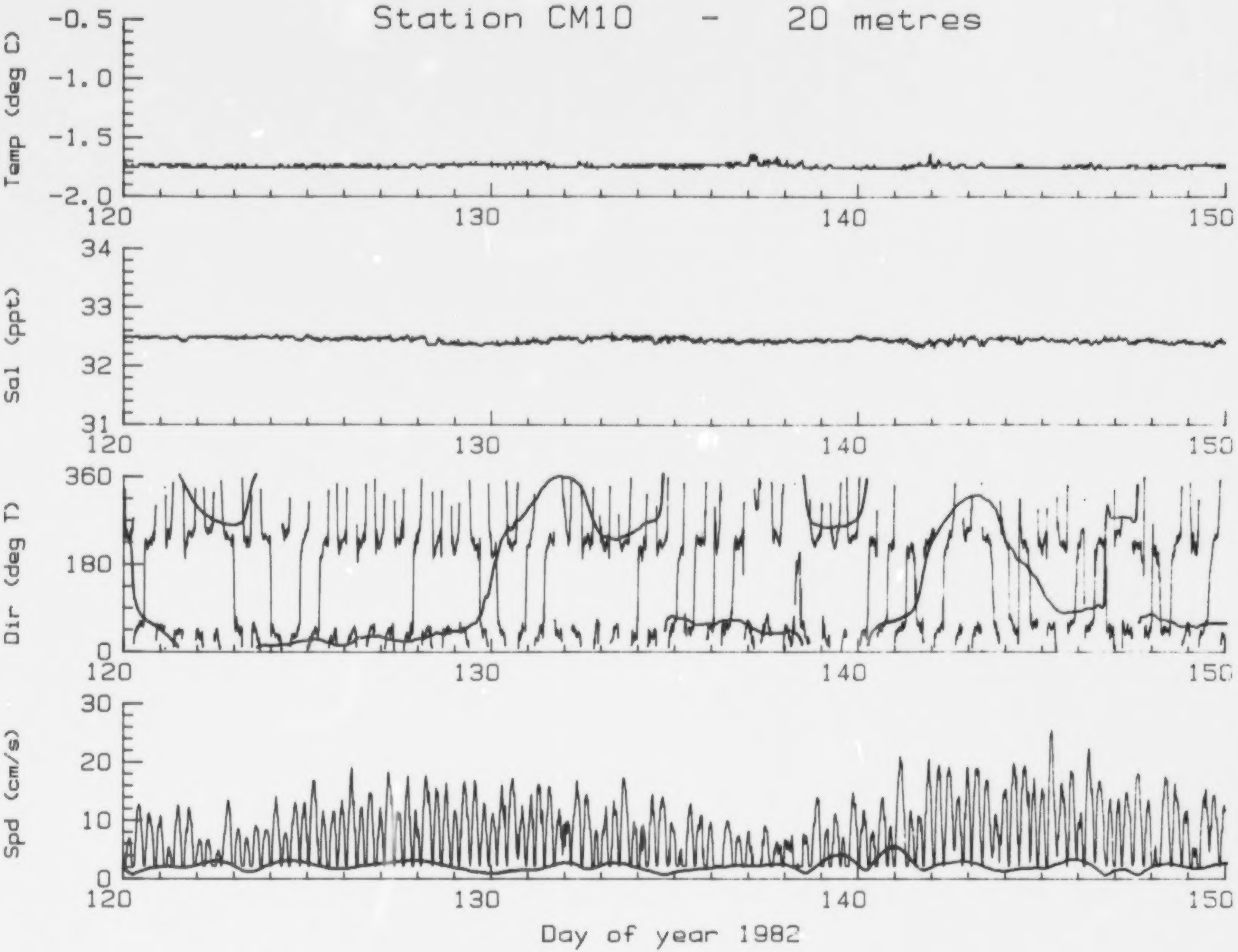


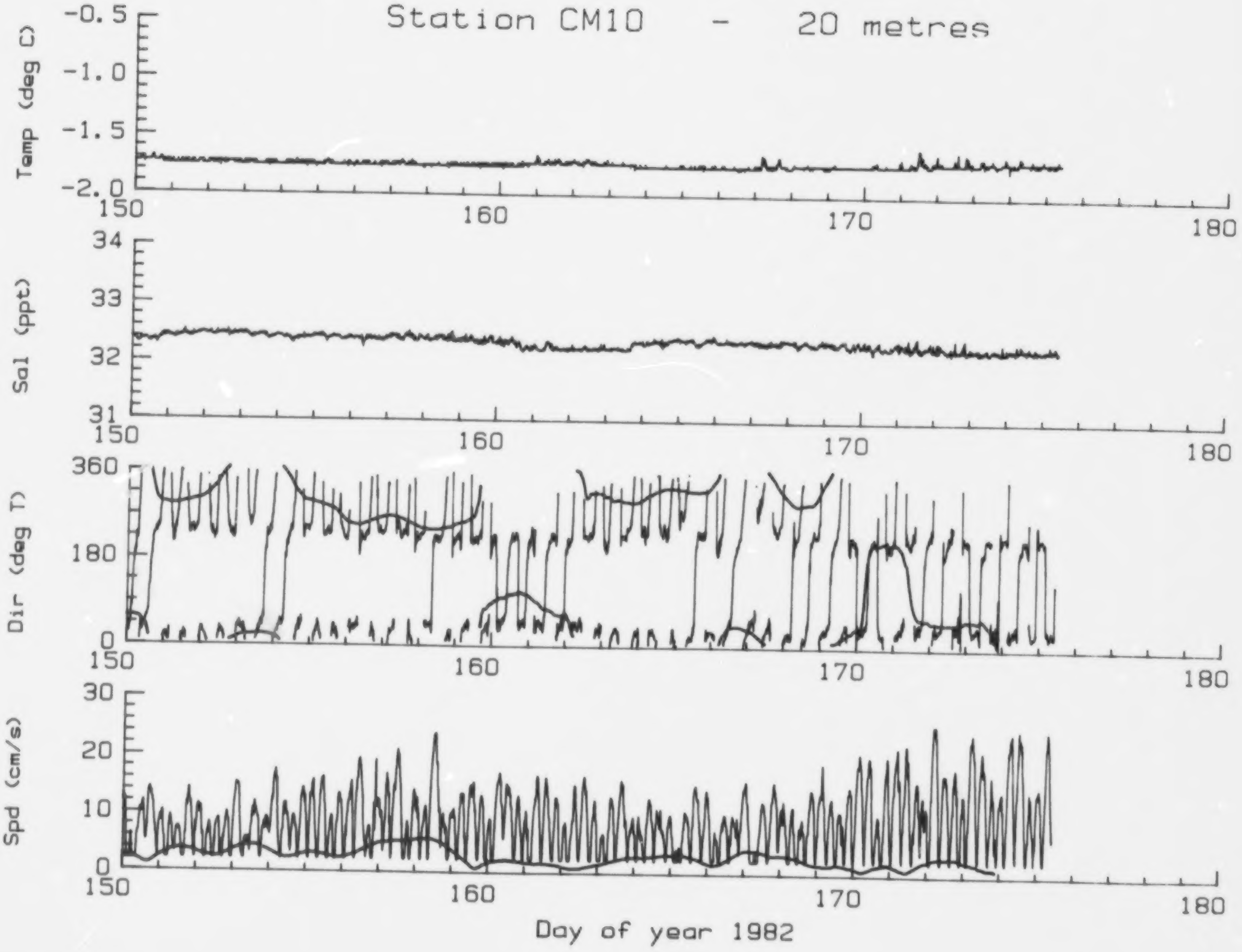

Station CM09 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

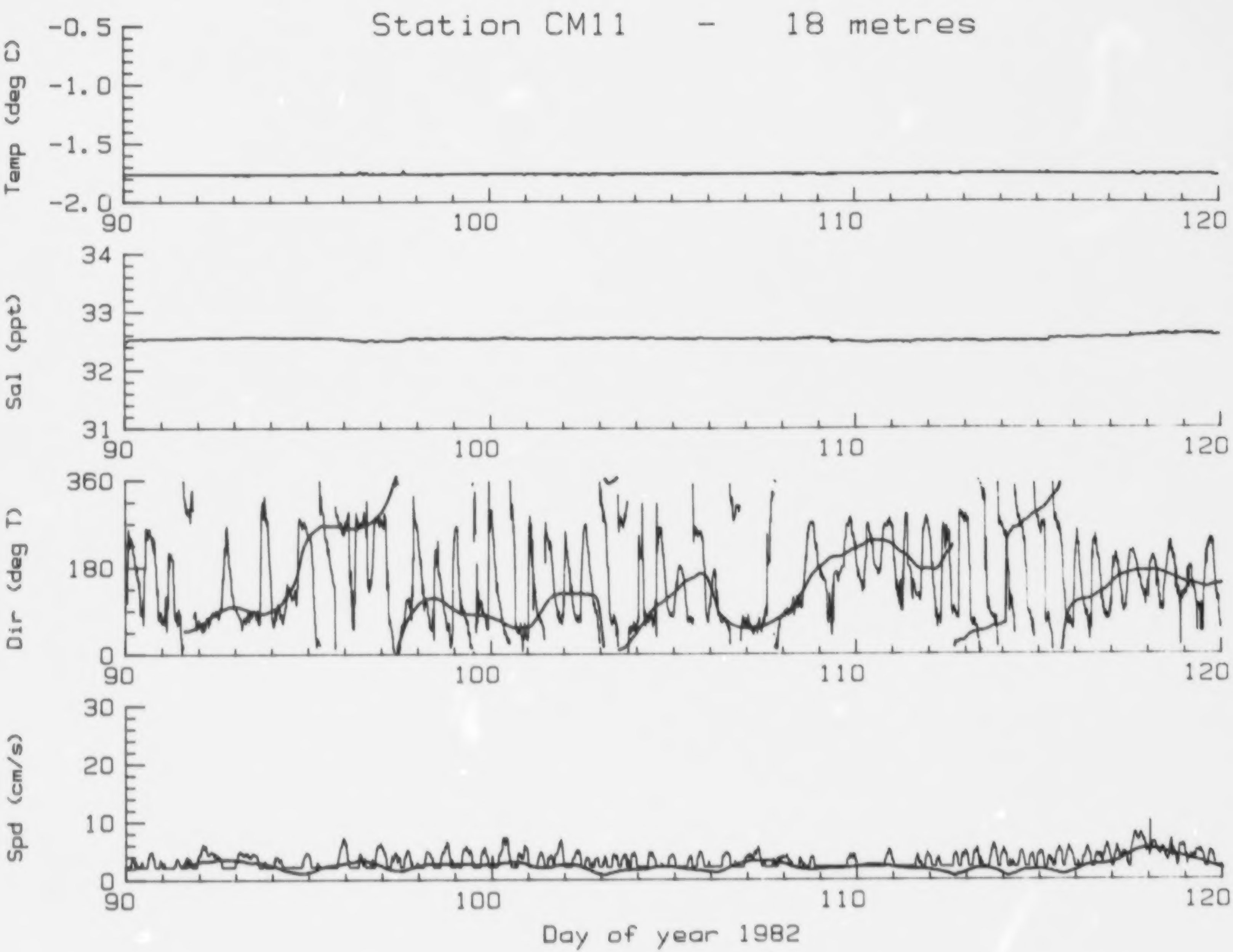


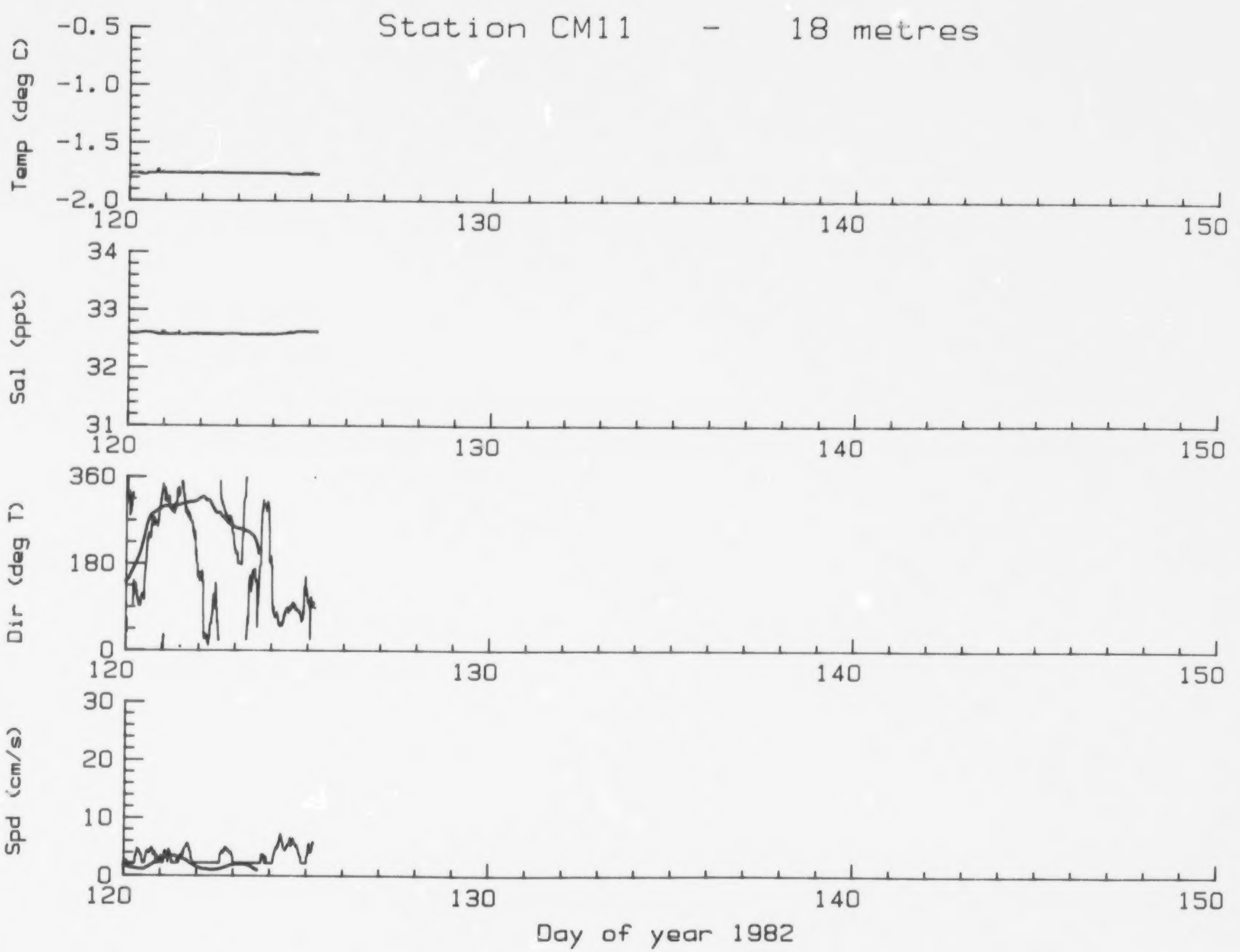
Station CM10 - 20 metres

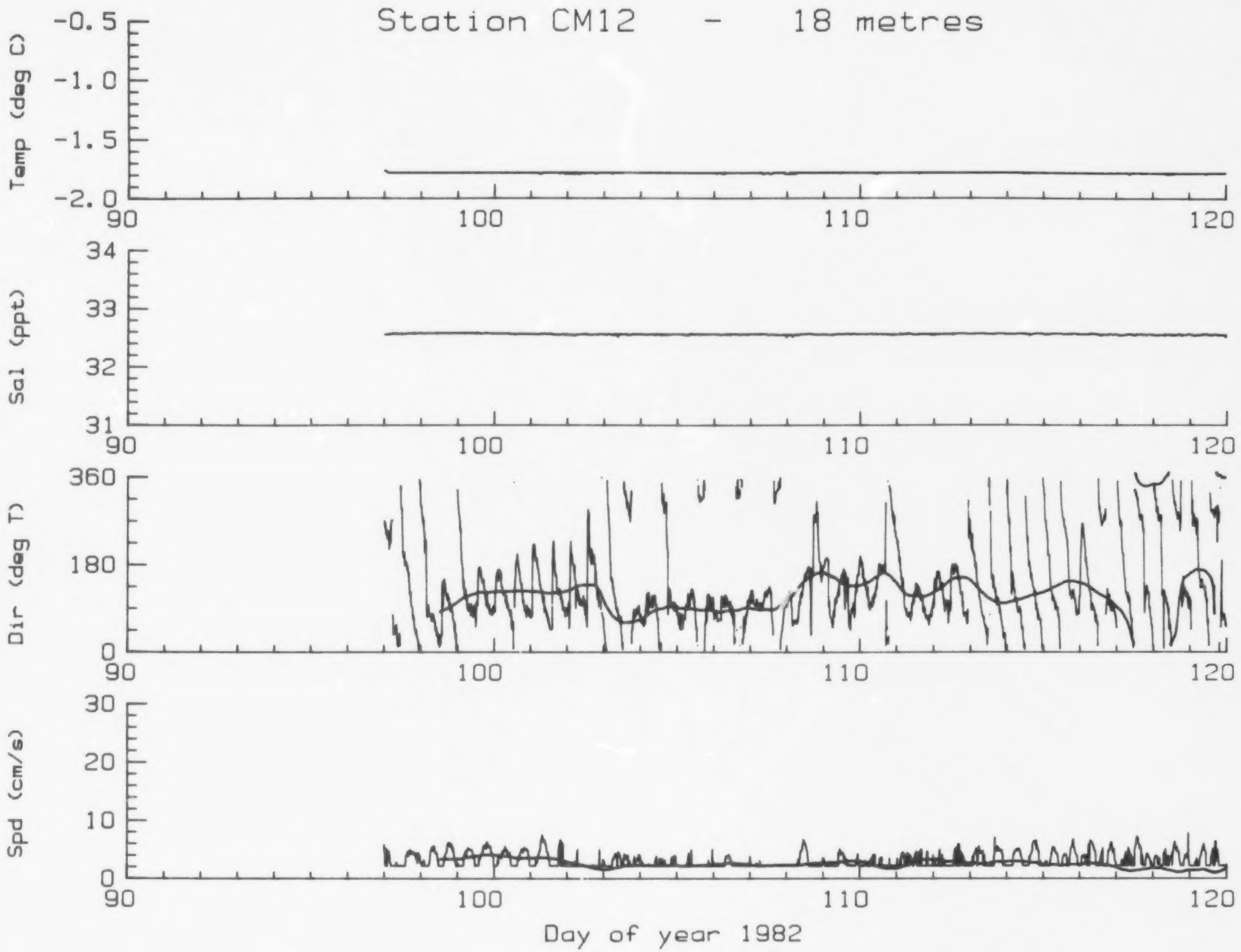

Station CM10 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982


Station CM10 - 20 metres

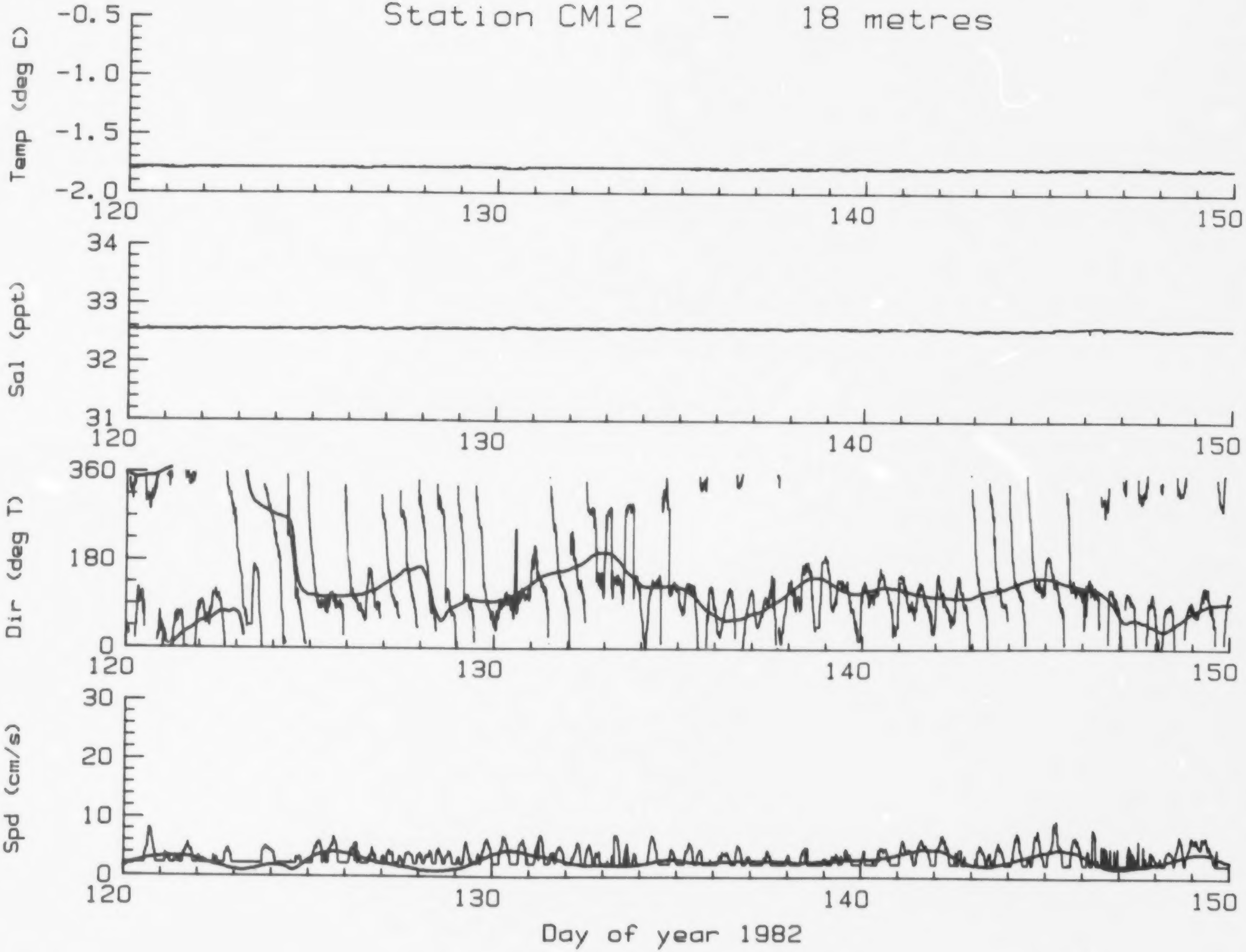

Station CM10 - 20 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

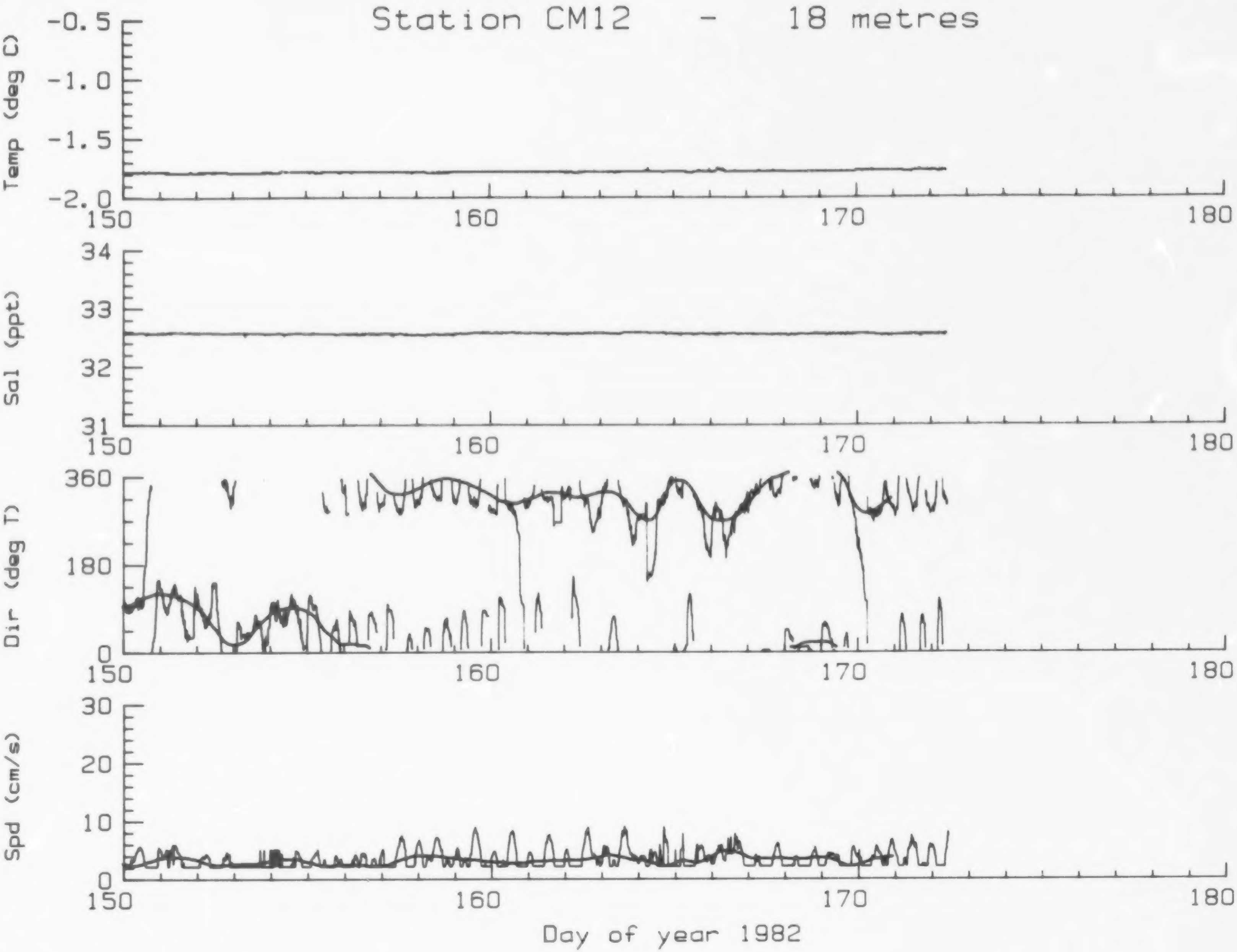

Station CM11 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

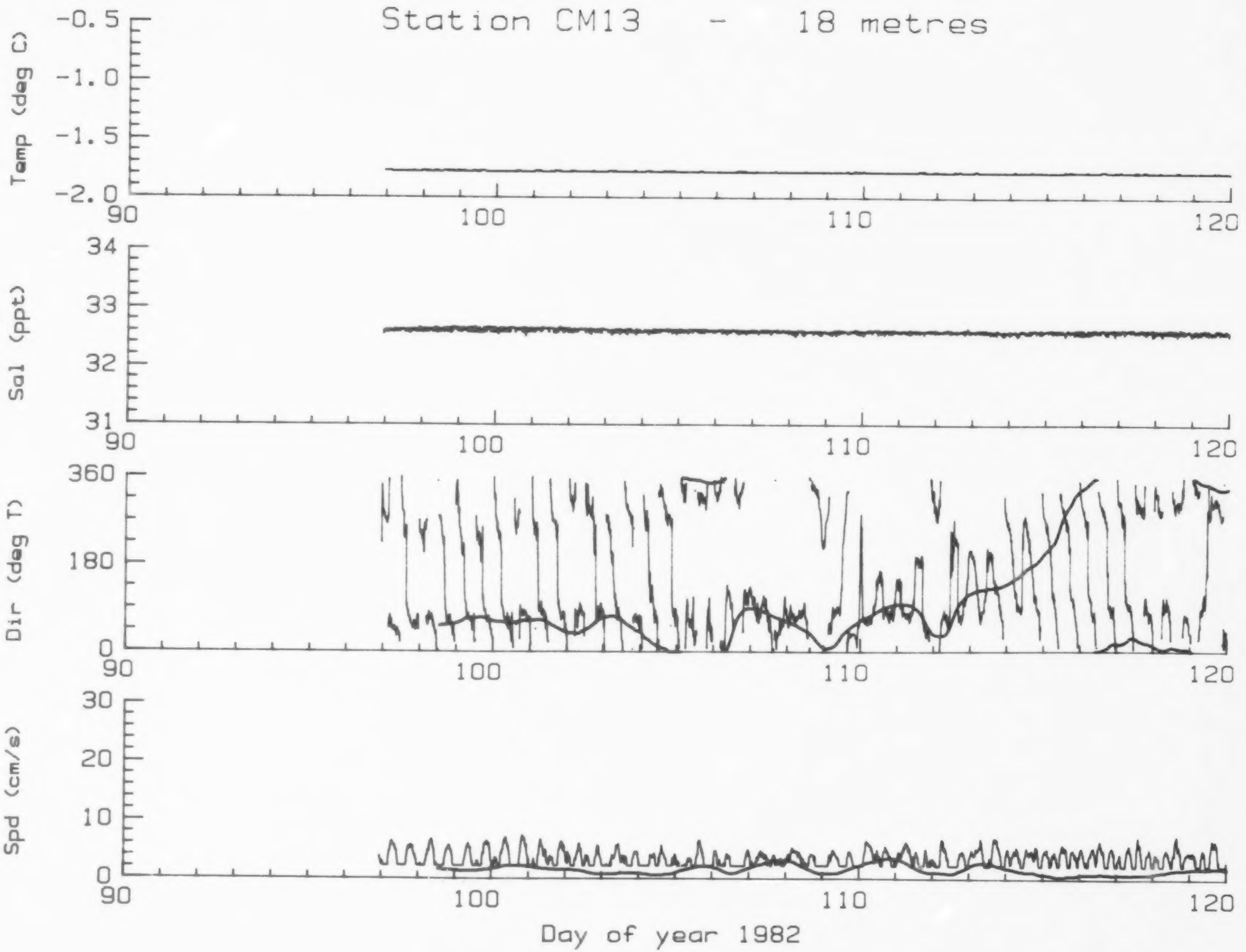

Station CM11 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

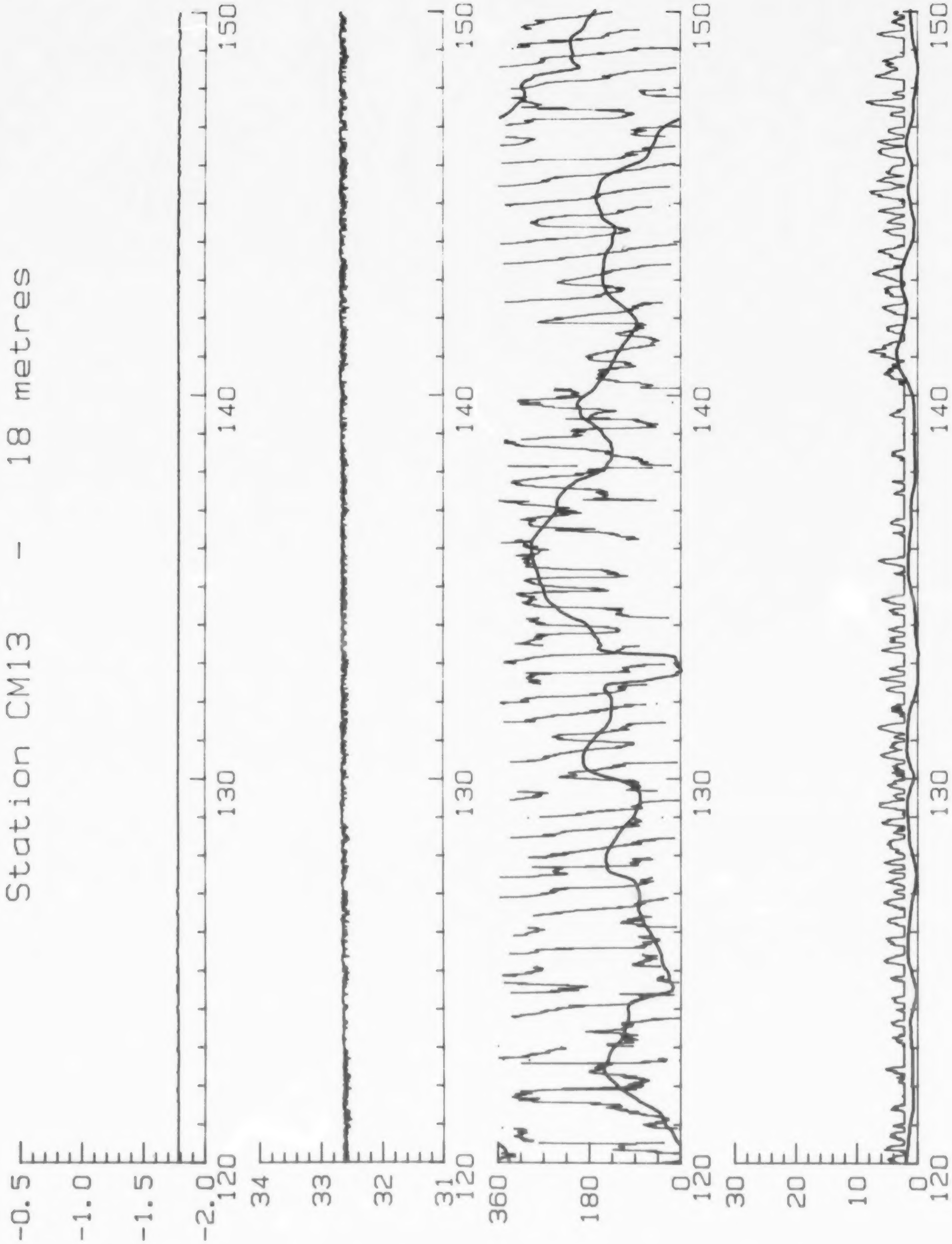


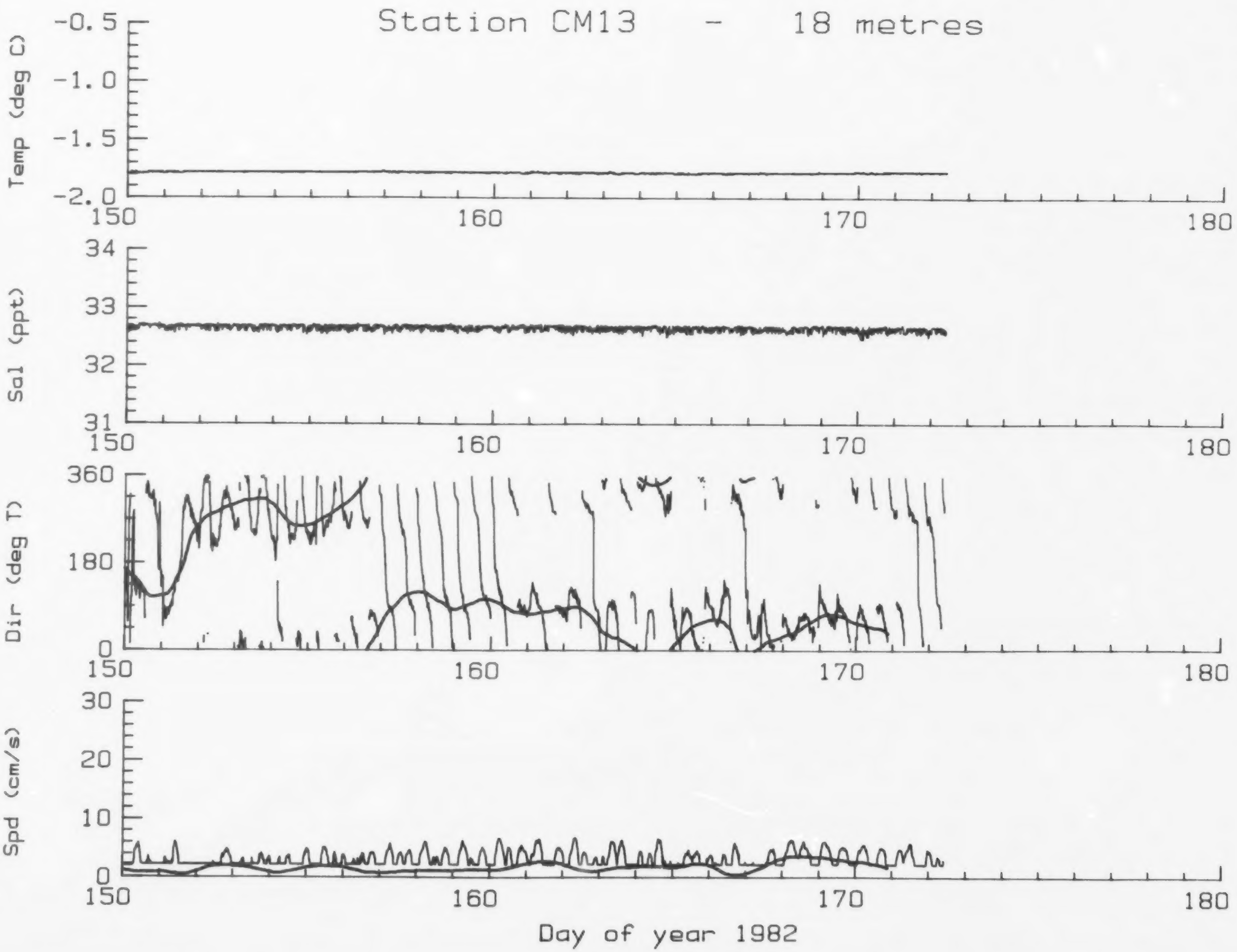
Station CM12 - 18 metres

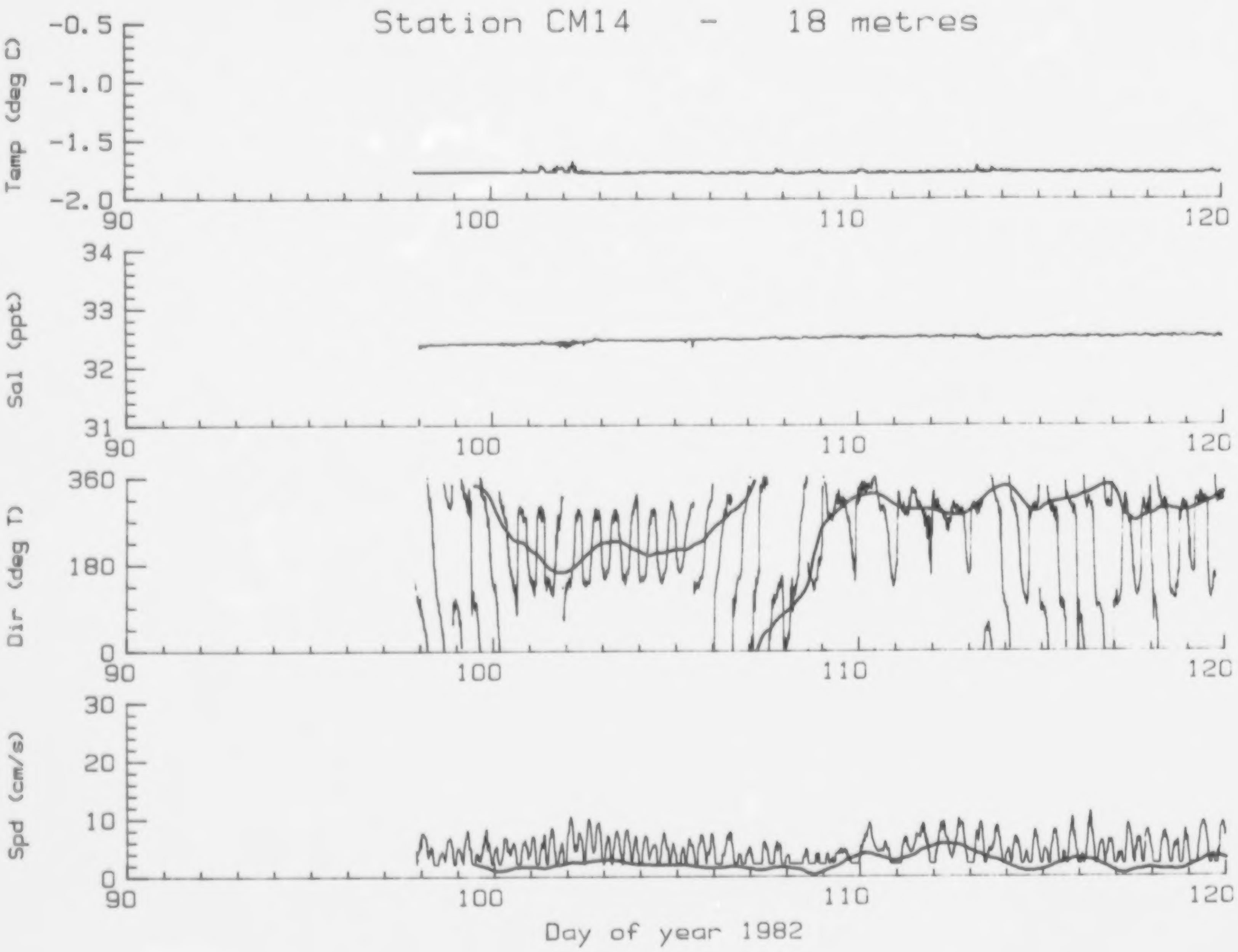

Station CM12 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

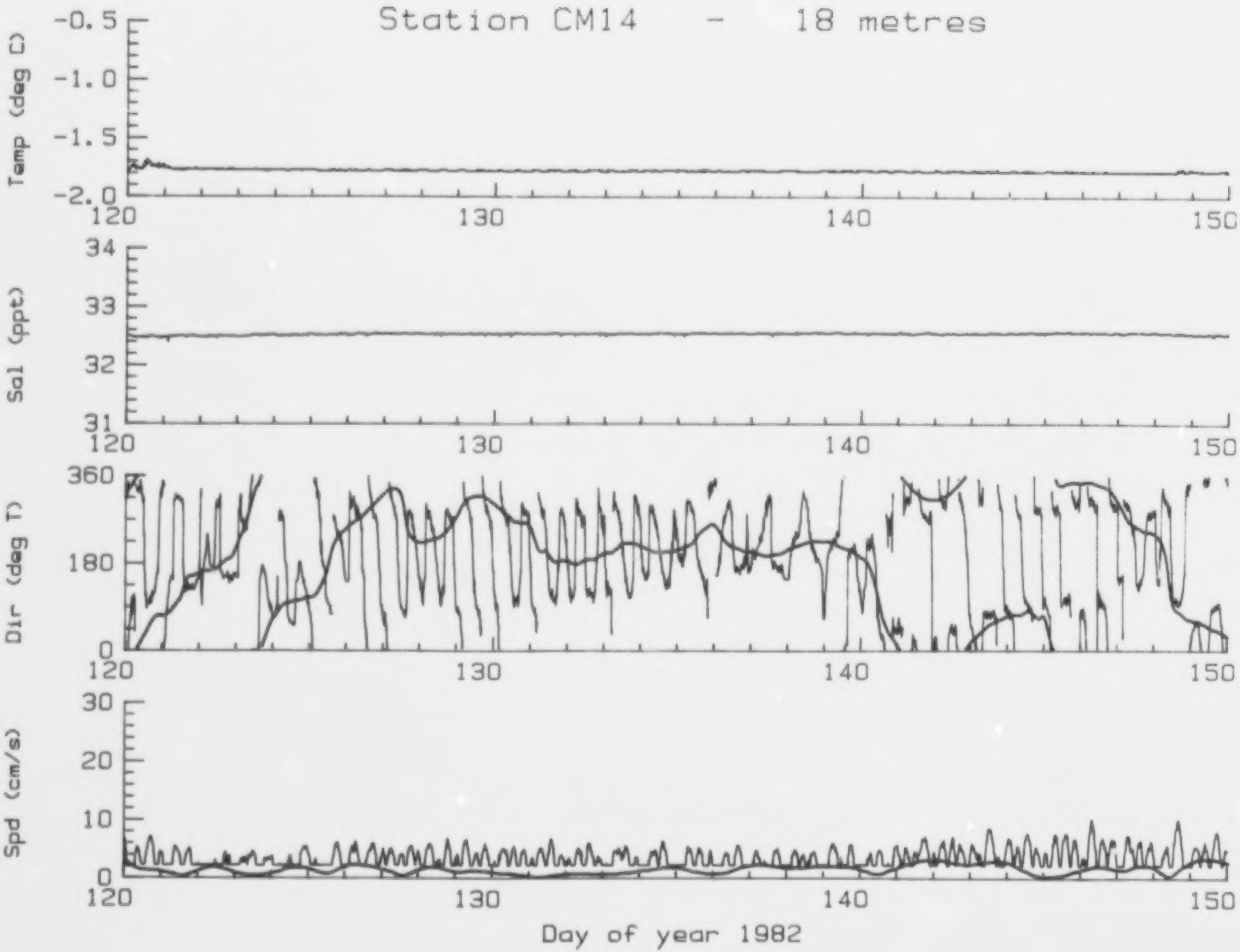

Station CM12 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

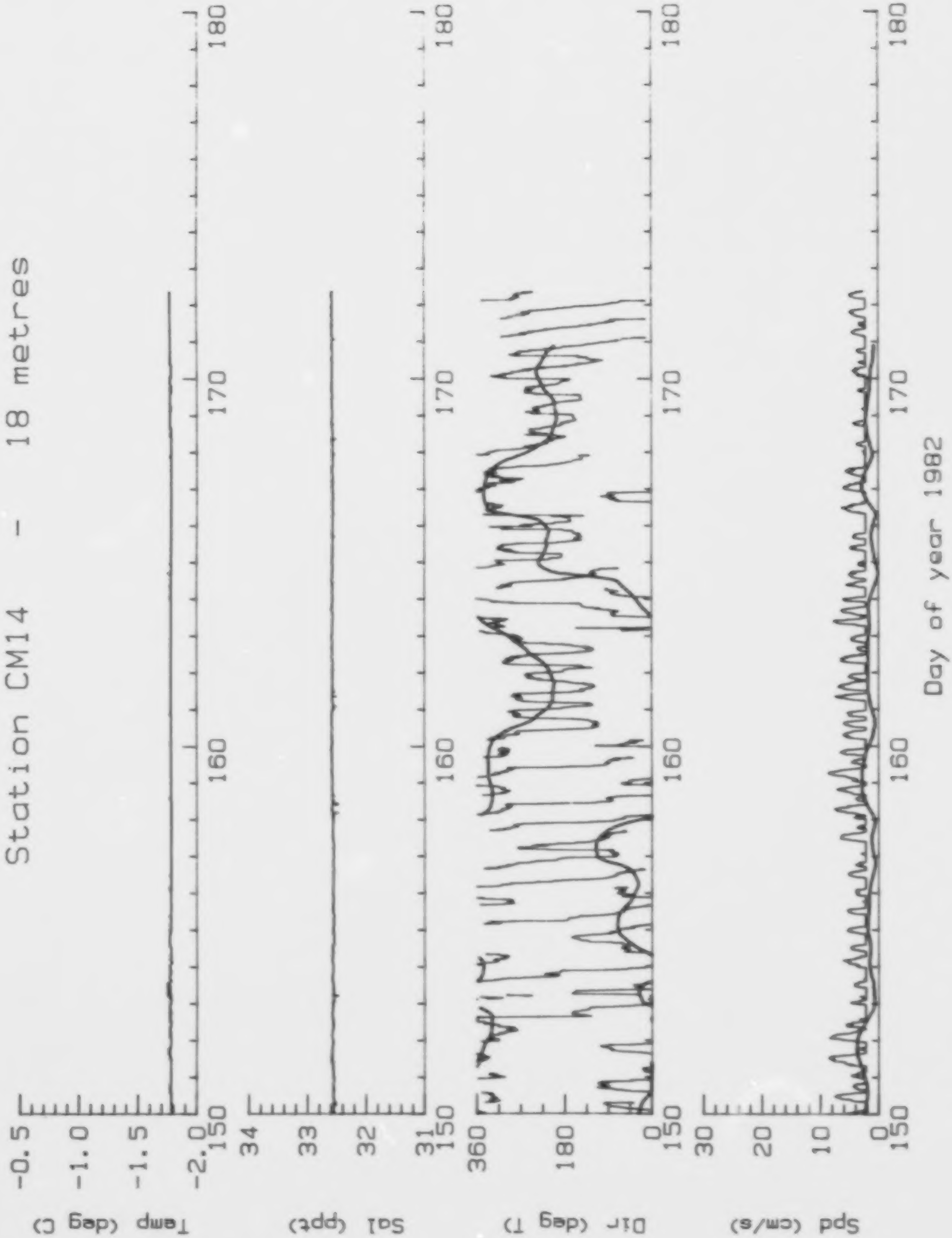

Station CM13 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

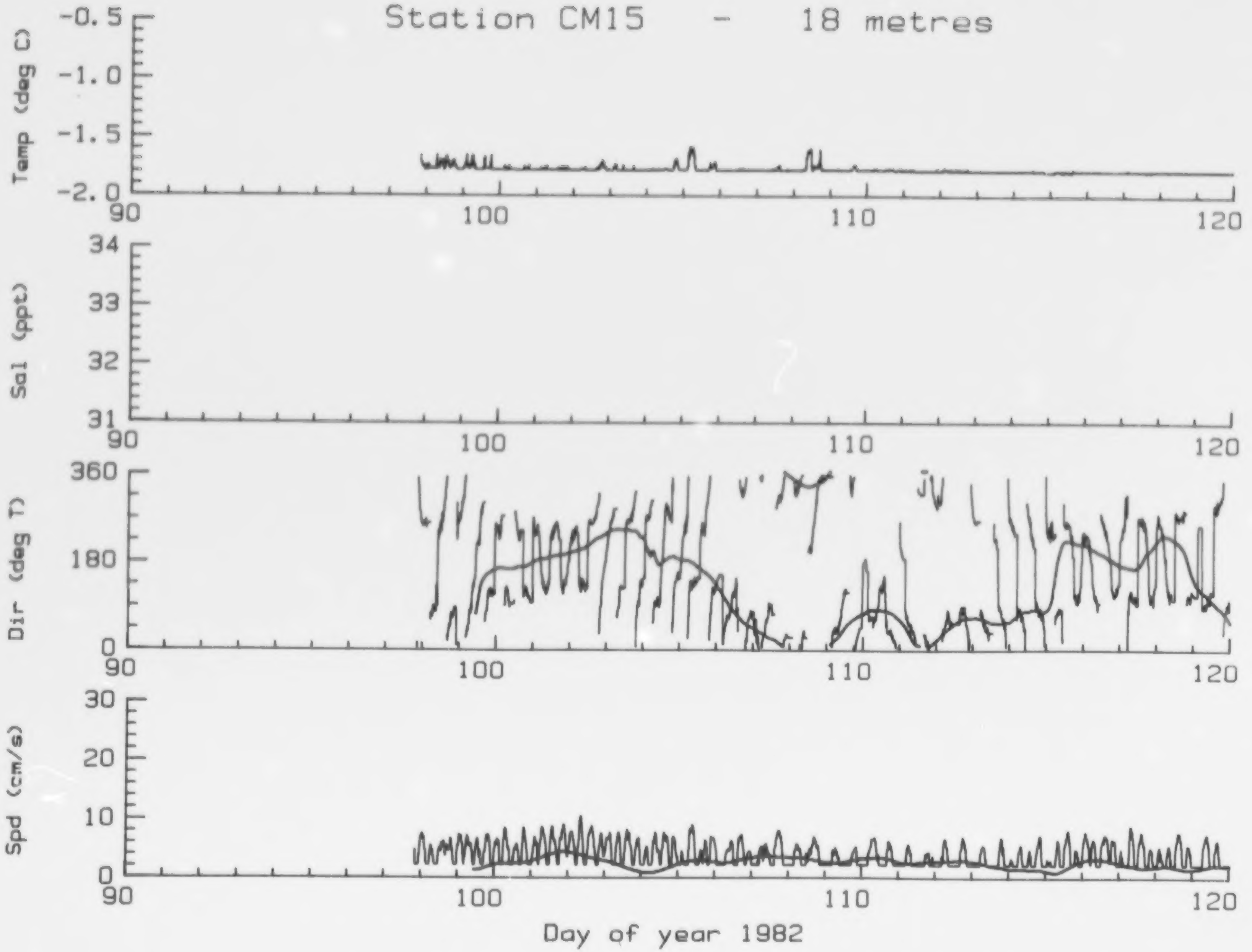

Station CM13 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

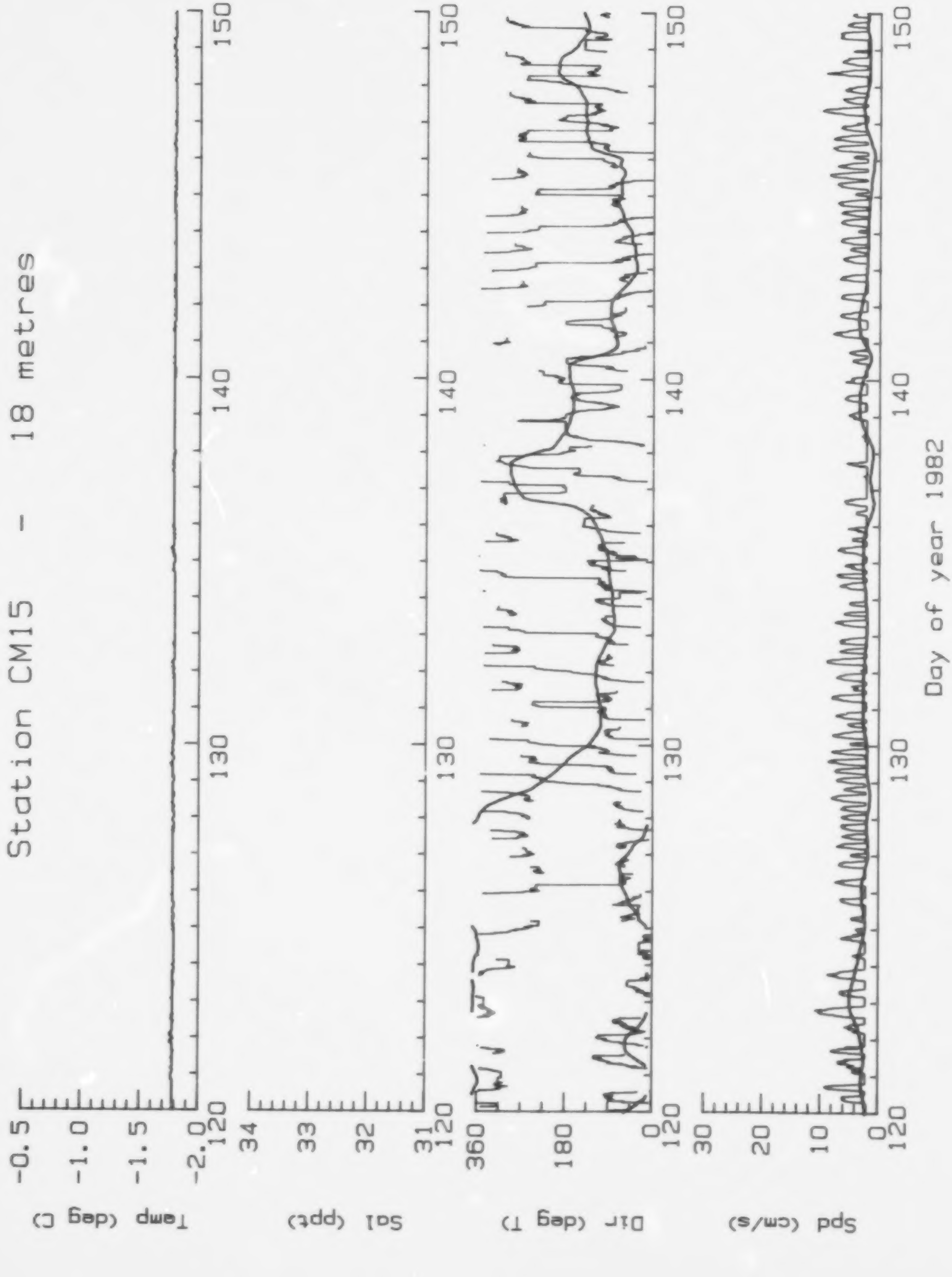

Station CM13 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

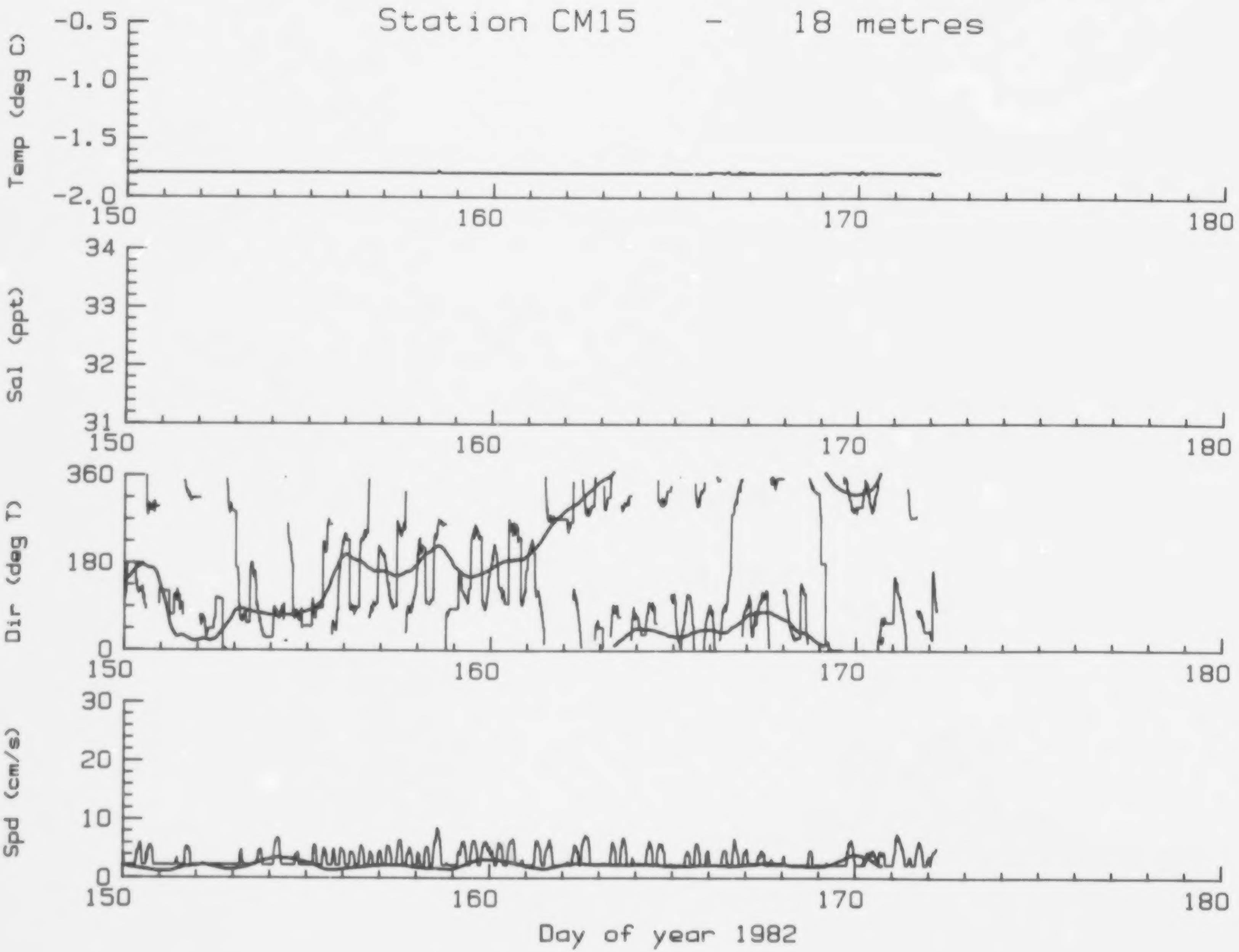

Station CM14 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

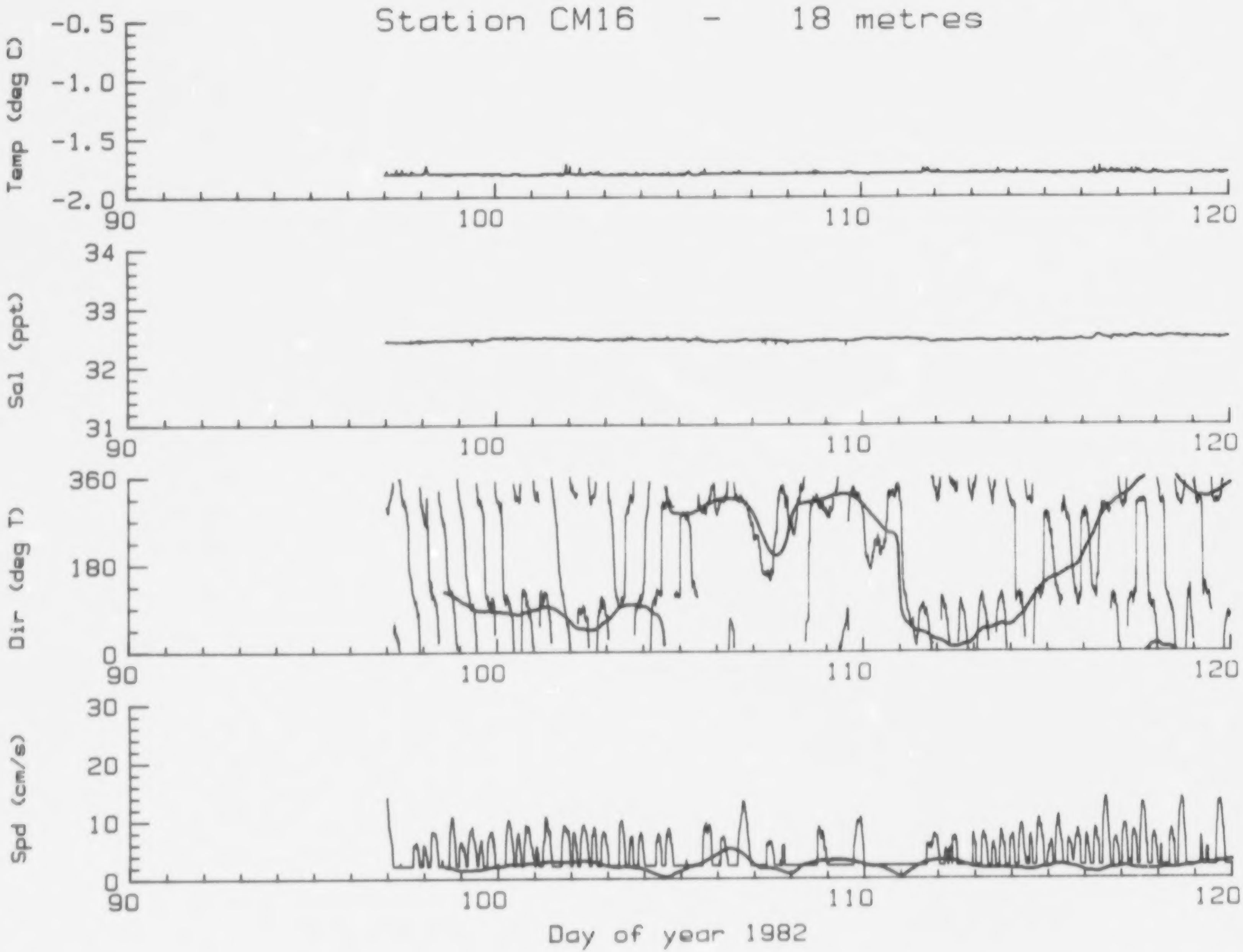

Station CM14 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

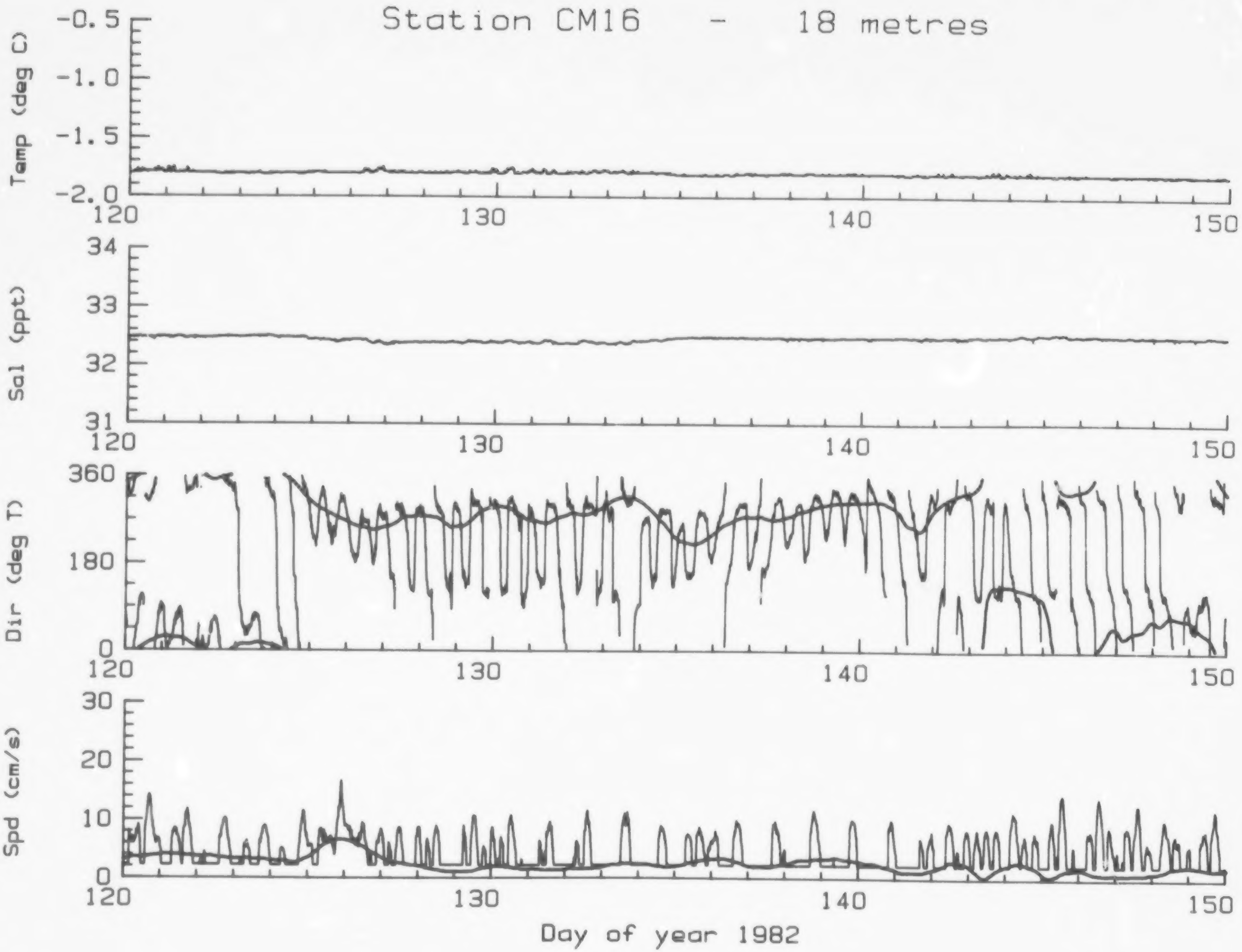

Station CM14 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

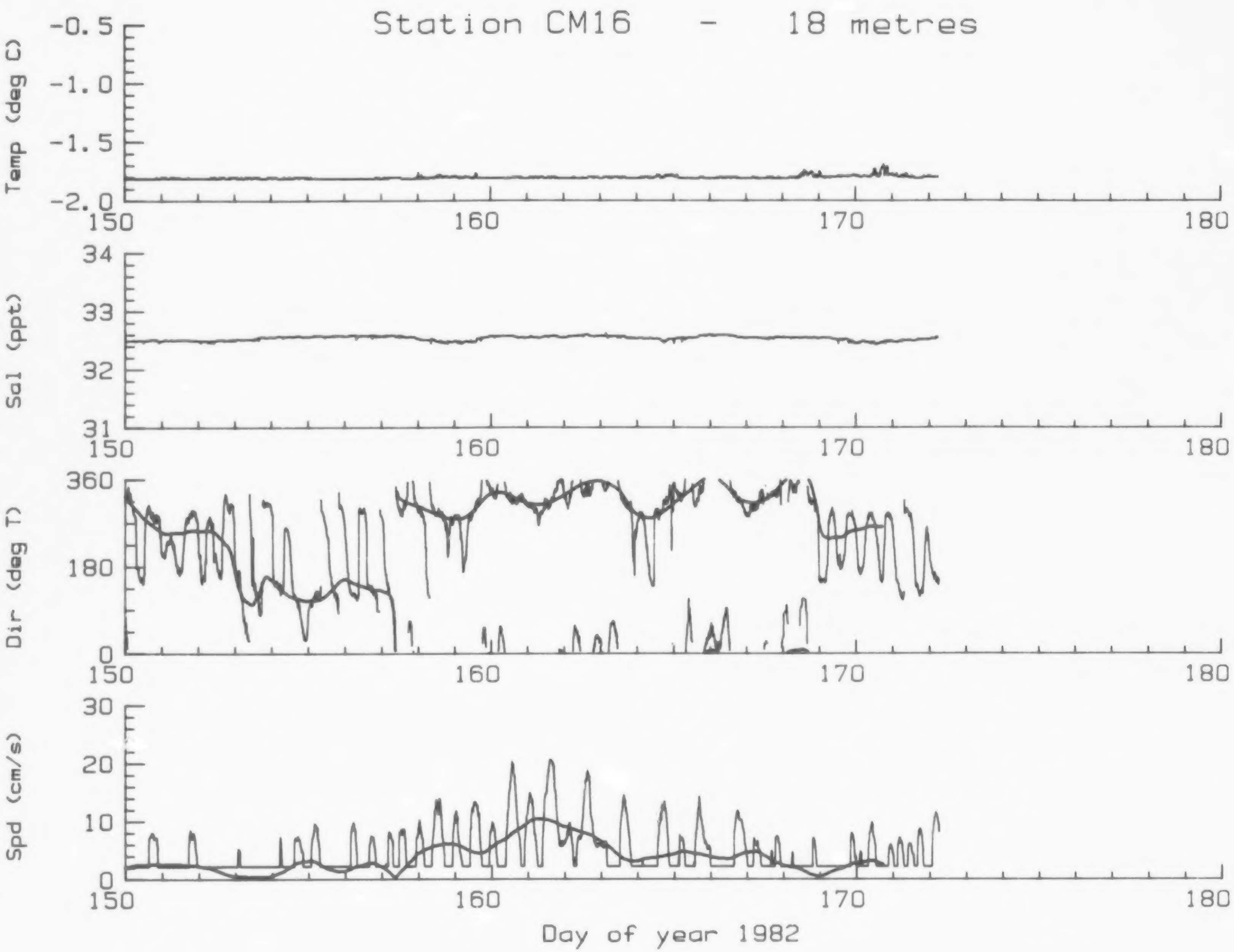

Station CM15 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

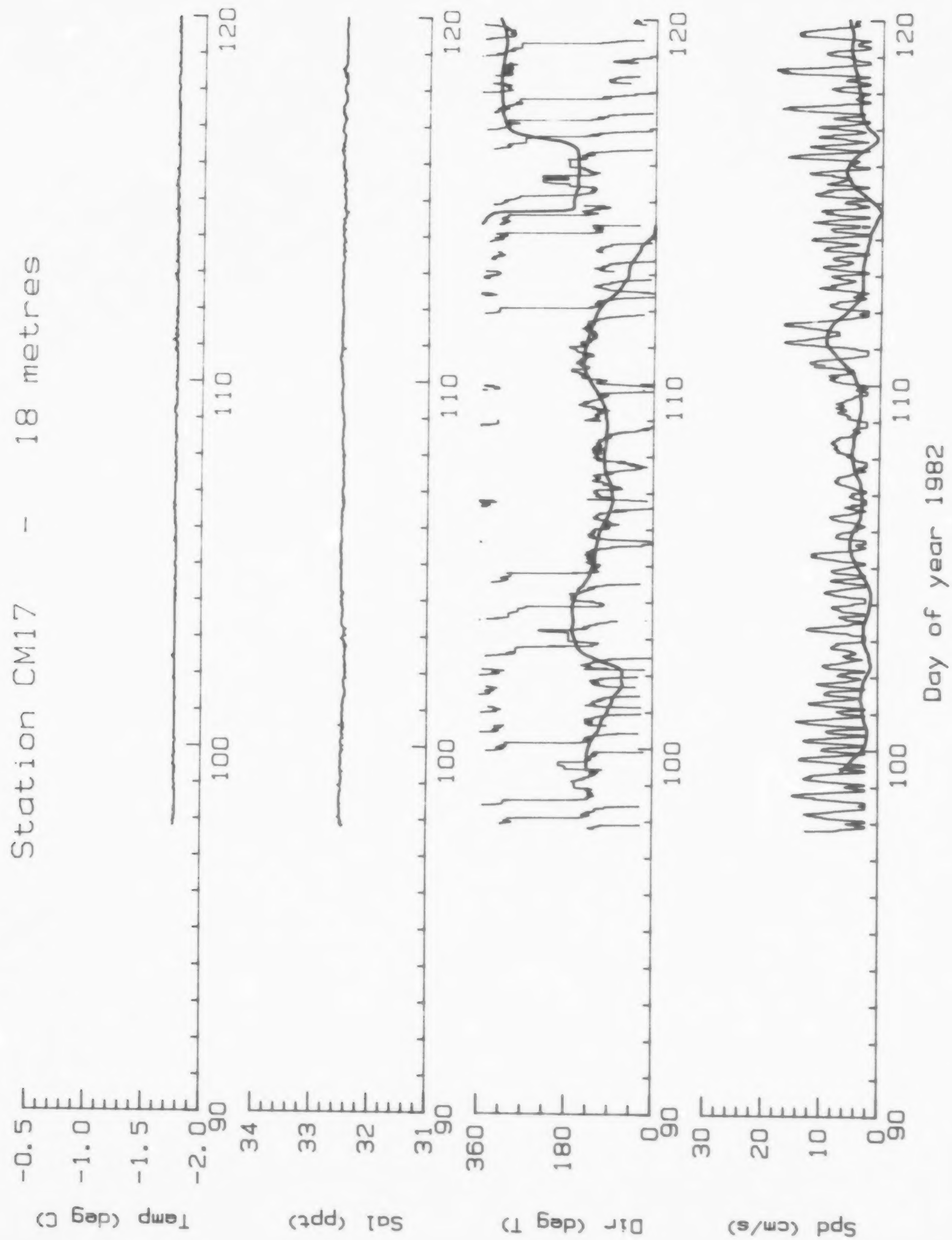

Station CM15 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

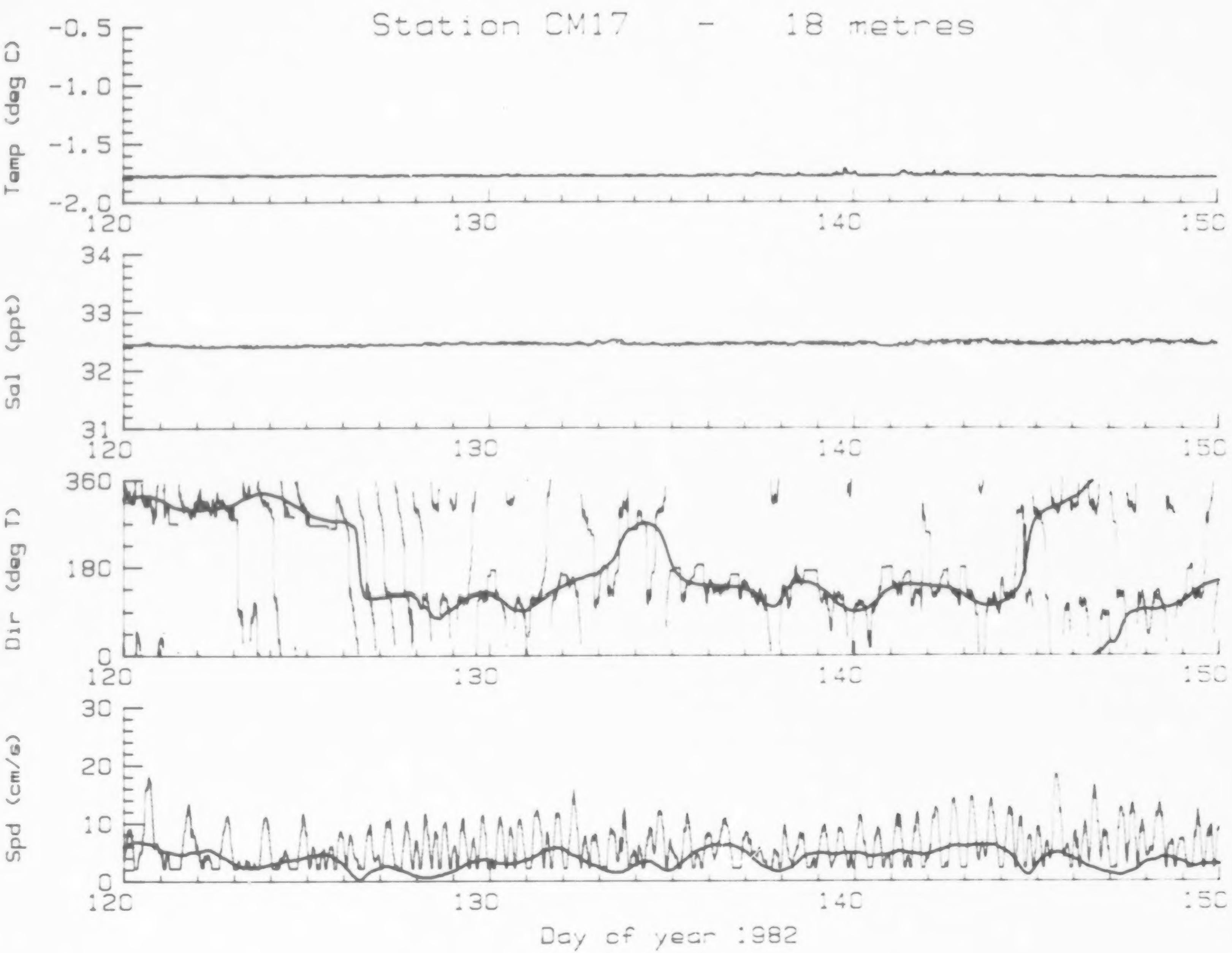

Station CM15 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

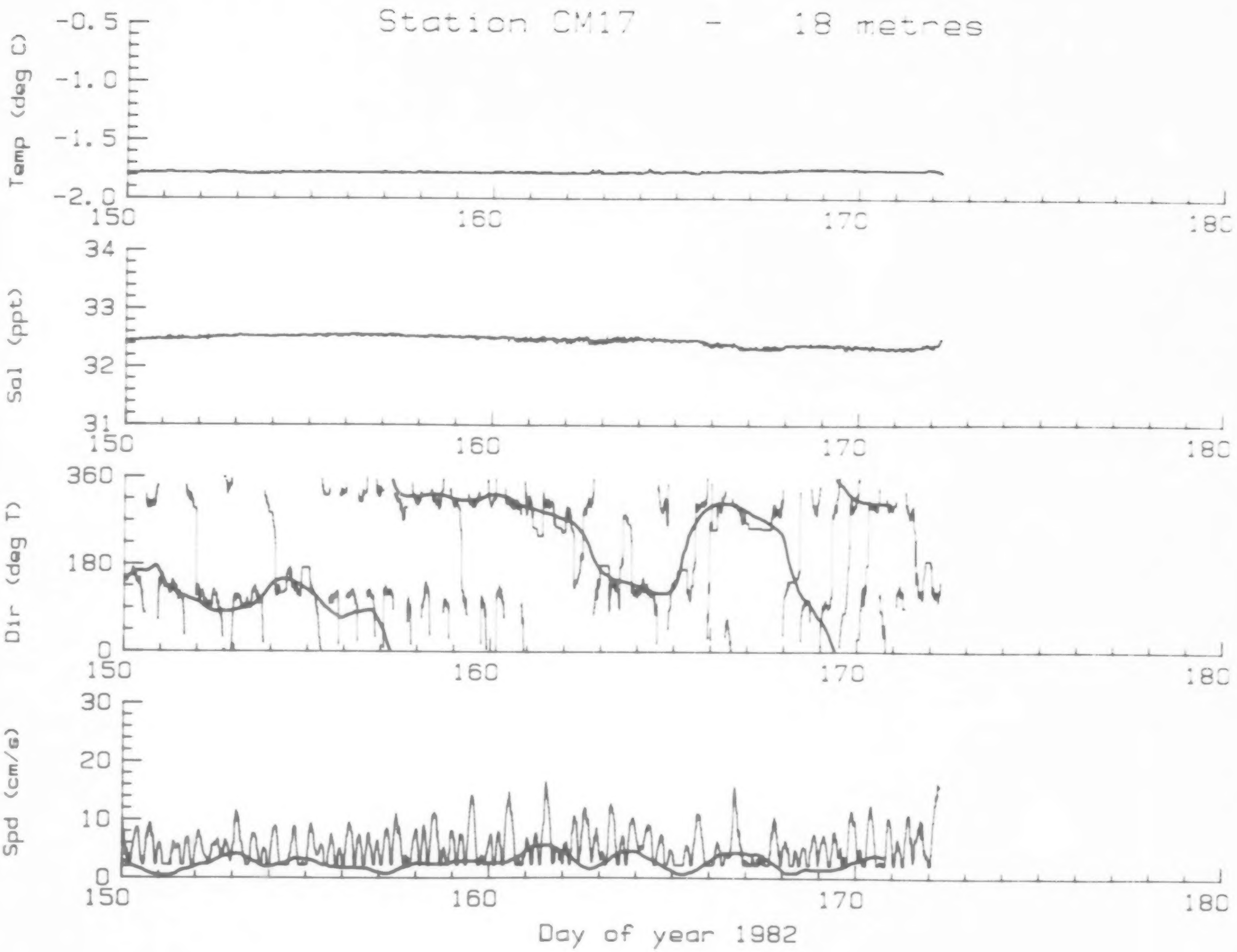

Station CM16 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

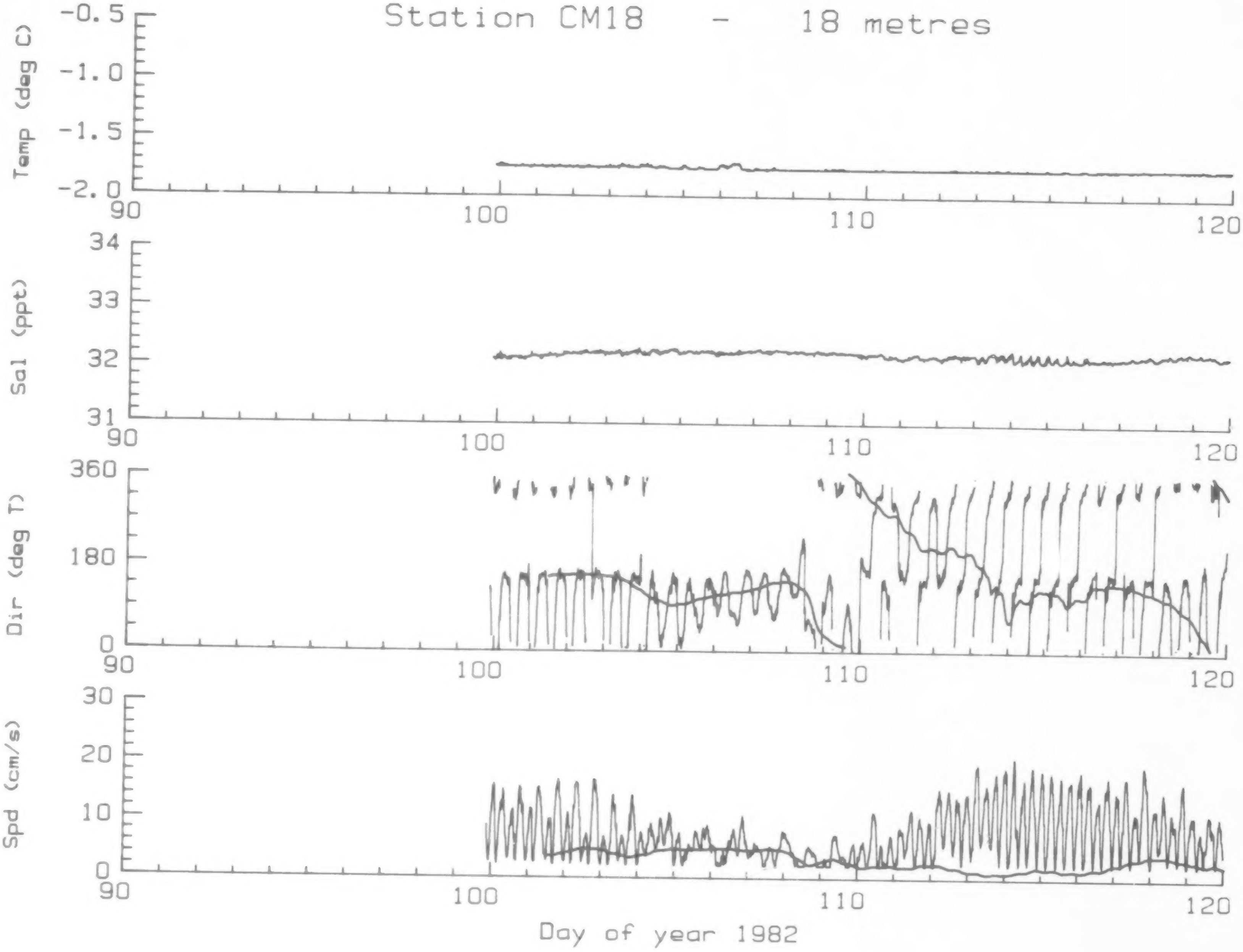

Station CM16 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

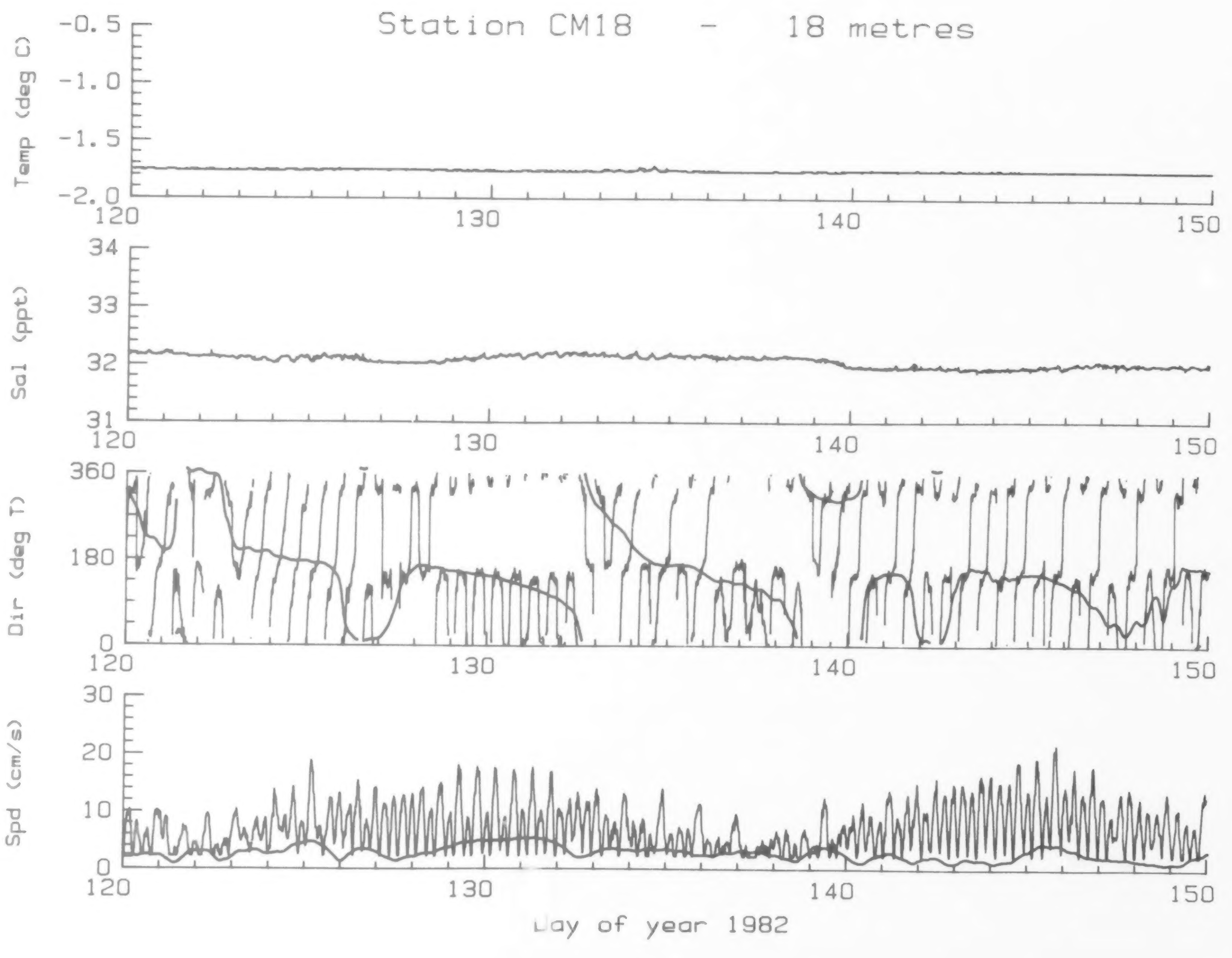

Station CM16 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

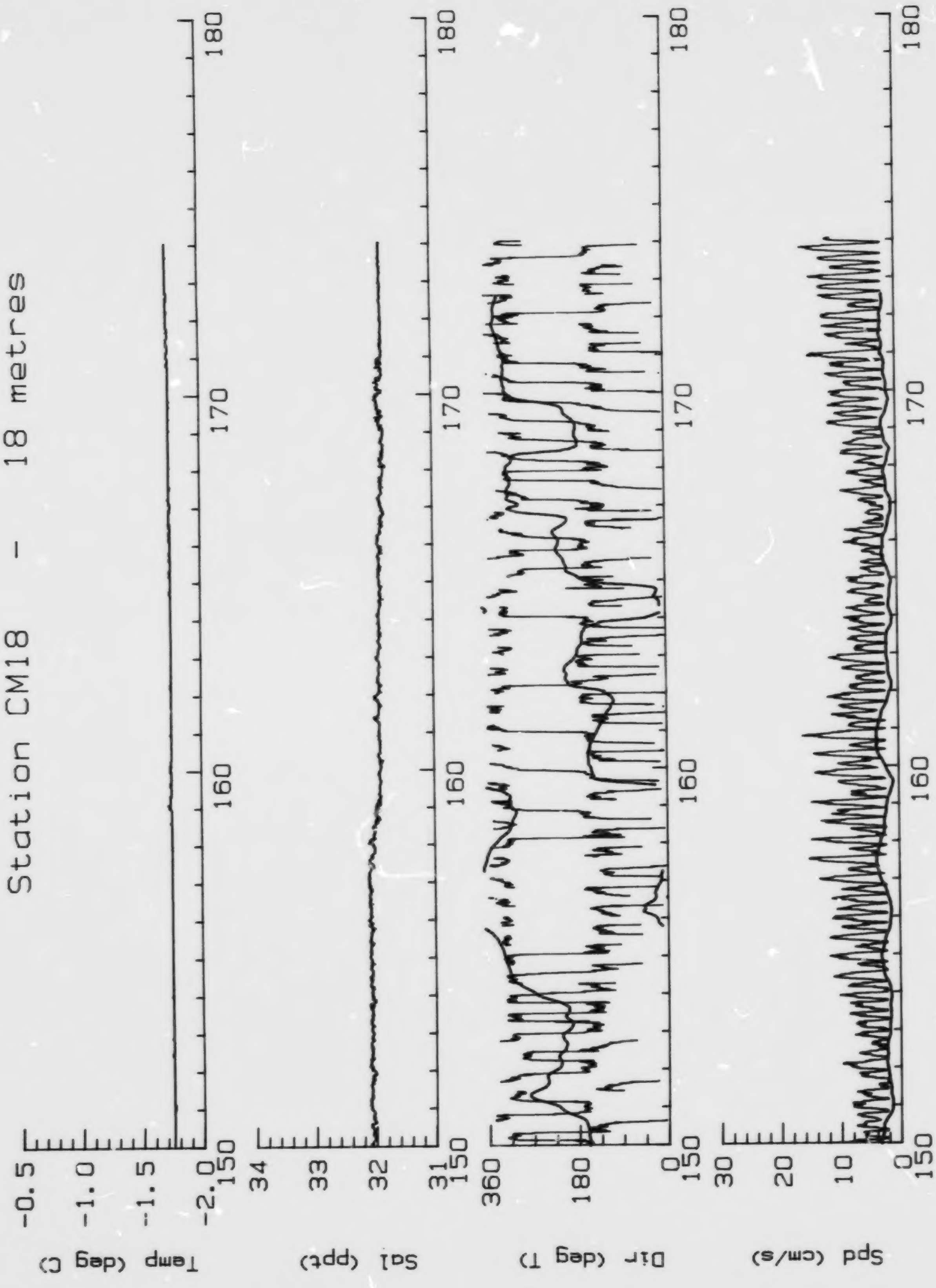

Station CM17 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

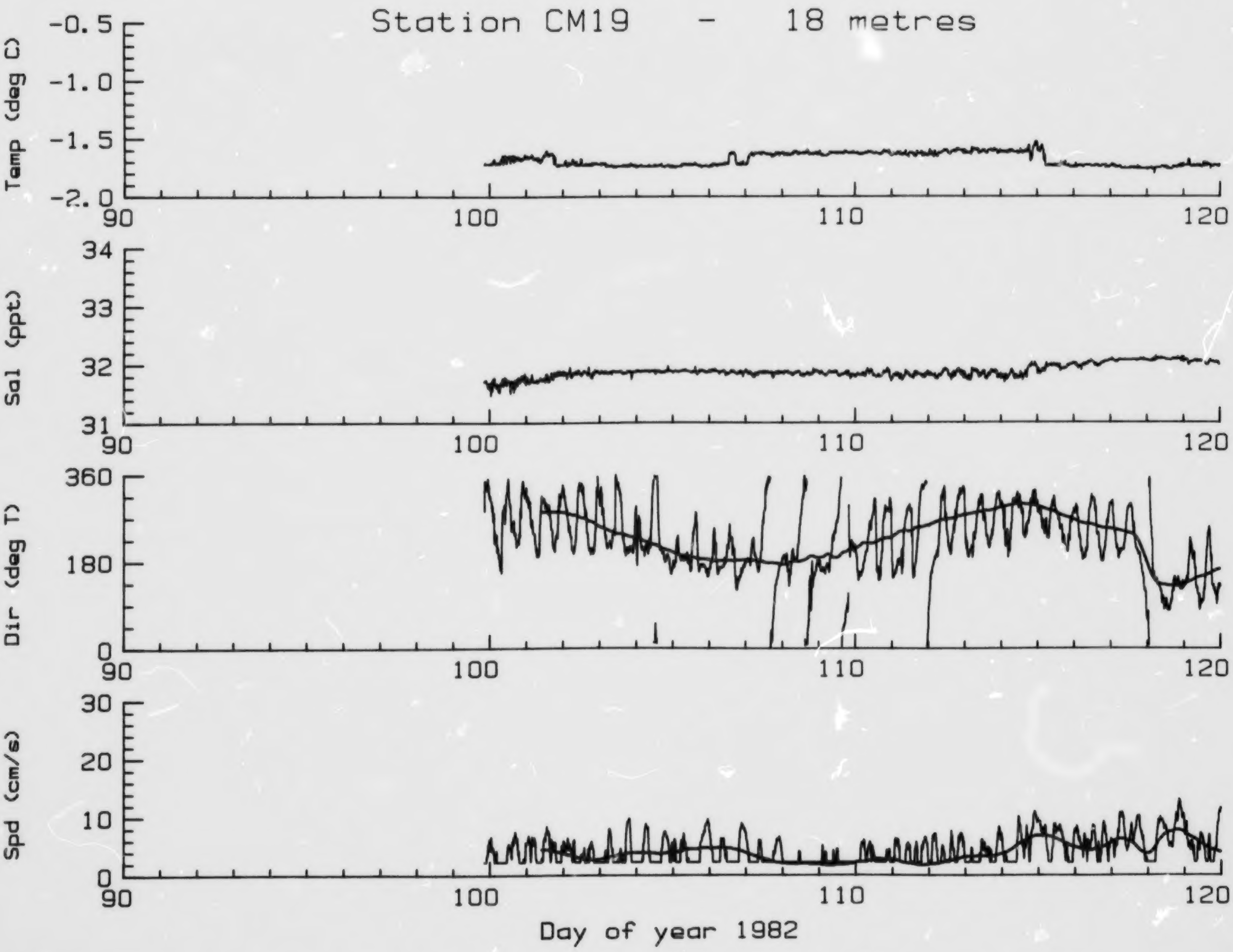

Station CM17 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

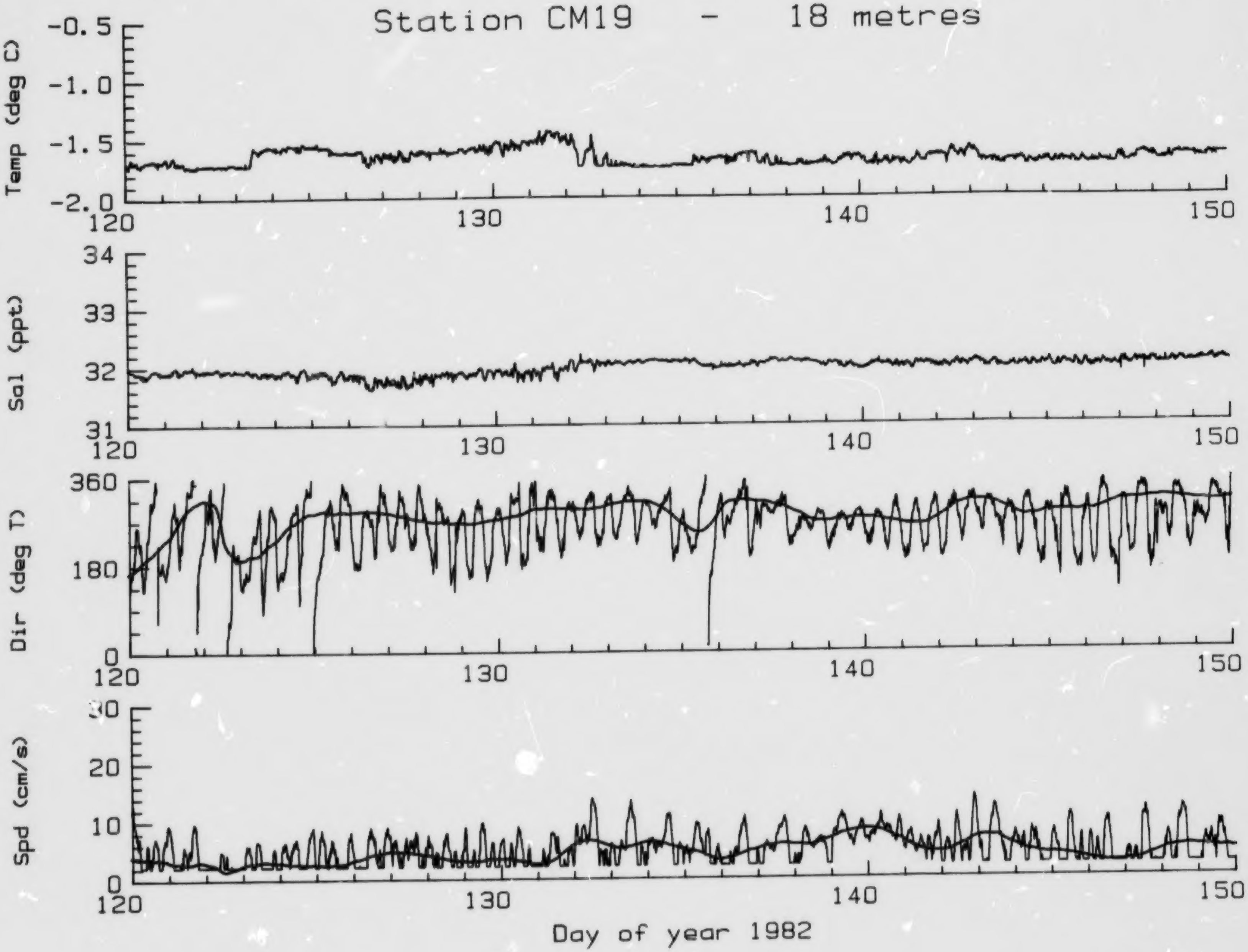

Station CM17 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

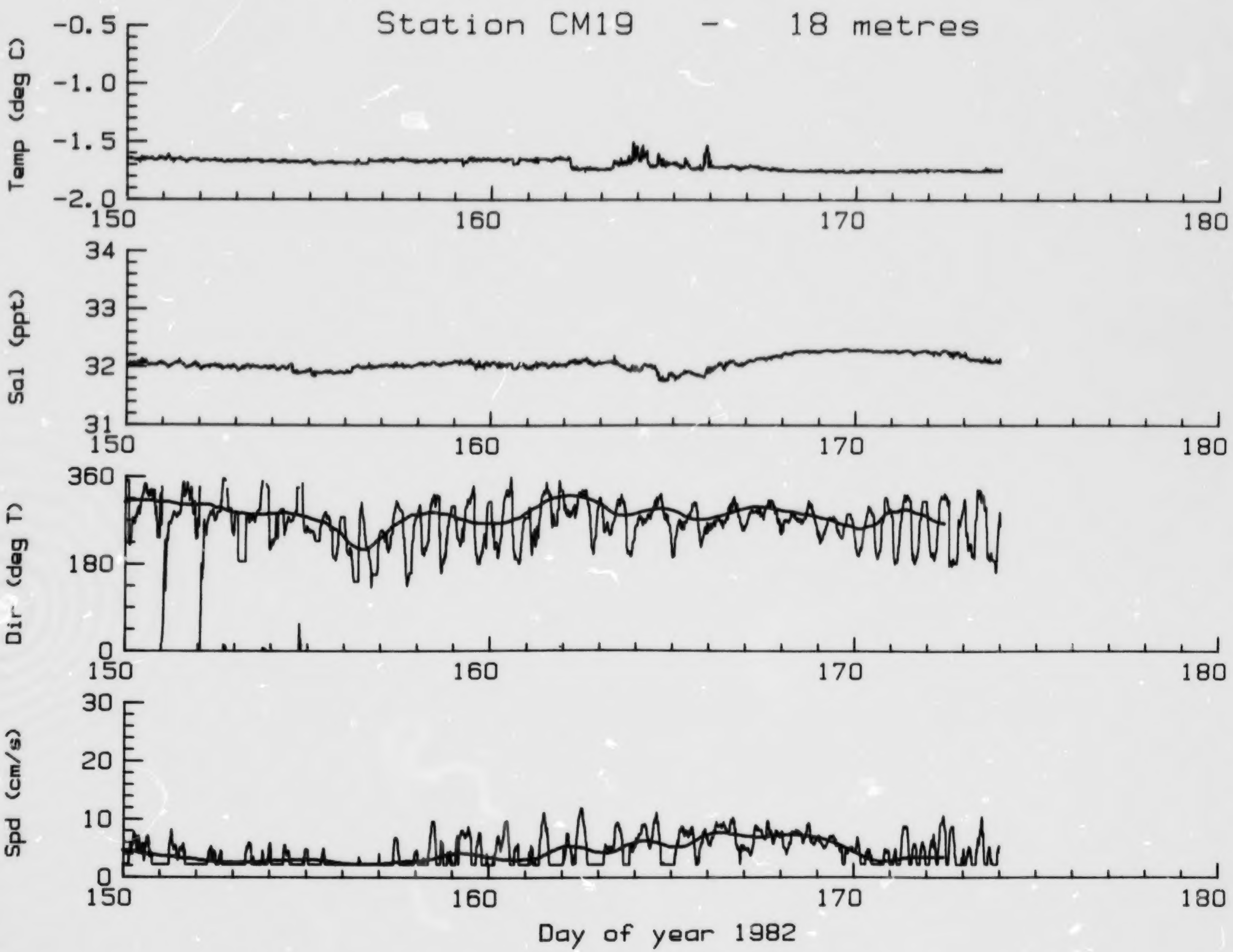

Station CM18 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

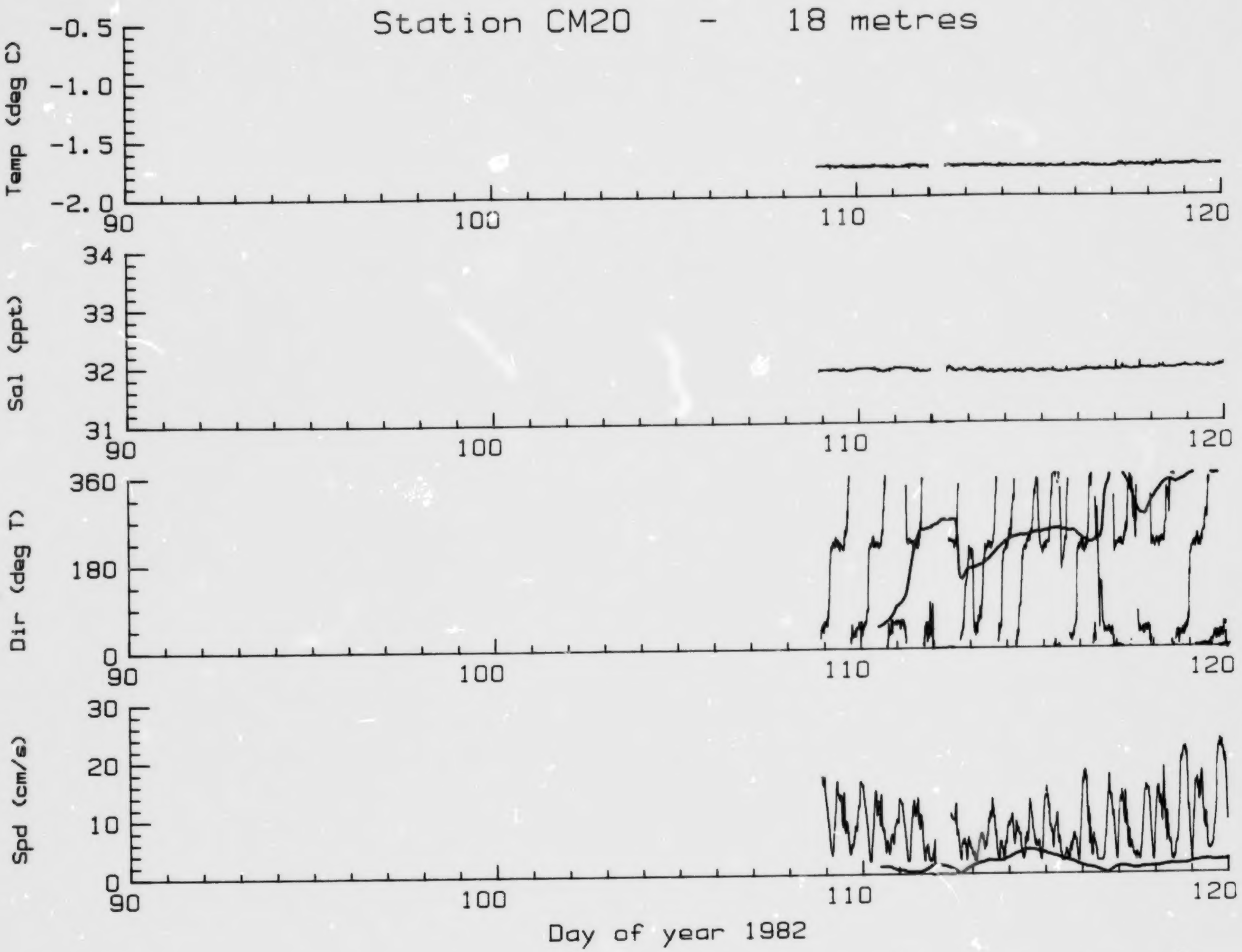

Station CM18 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

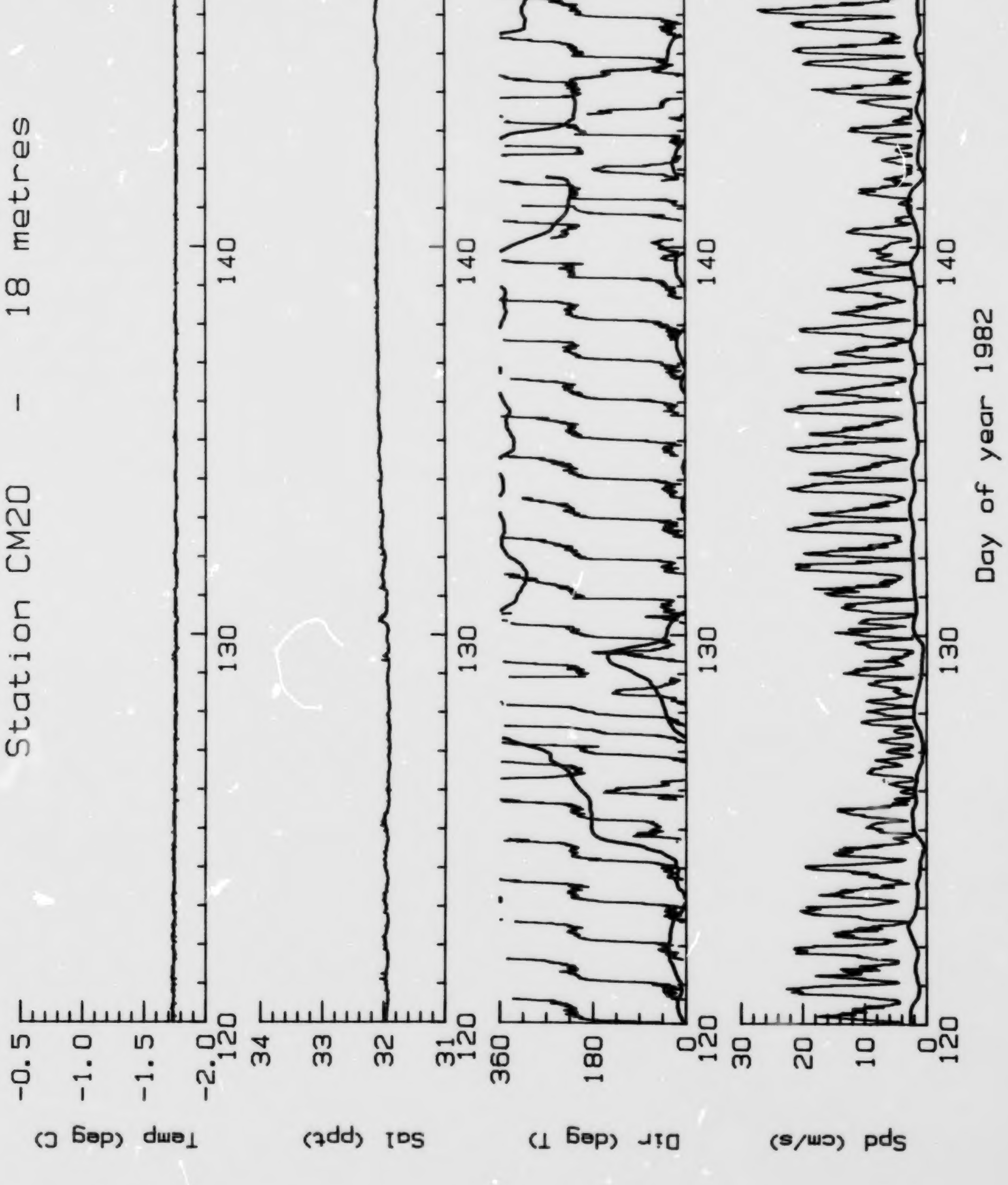

Station CM18 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

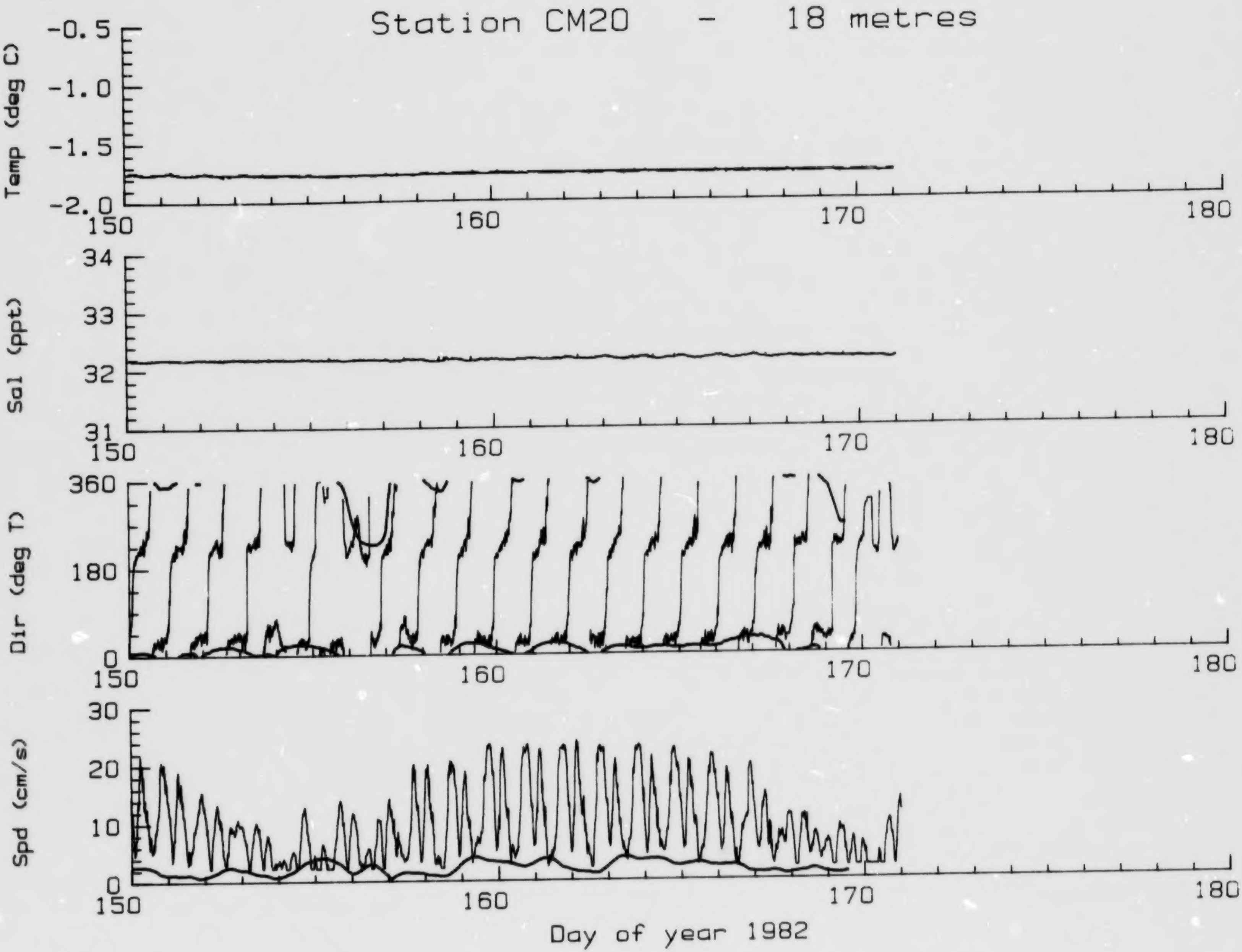

Station CM19 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

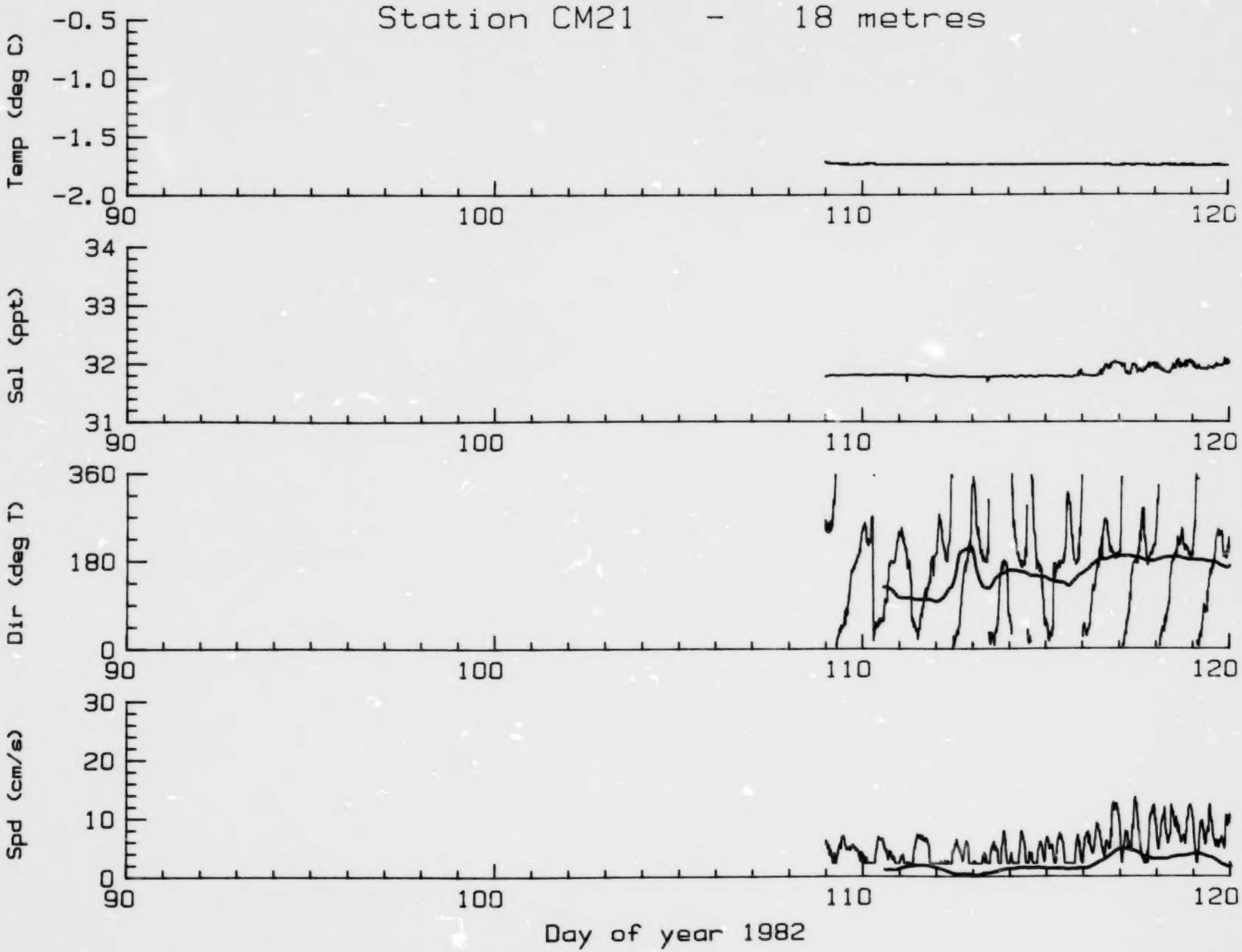

Station CM19 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

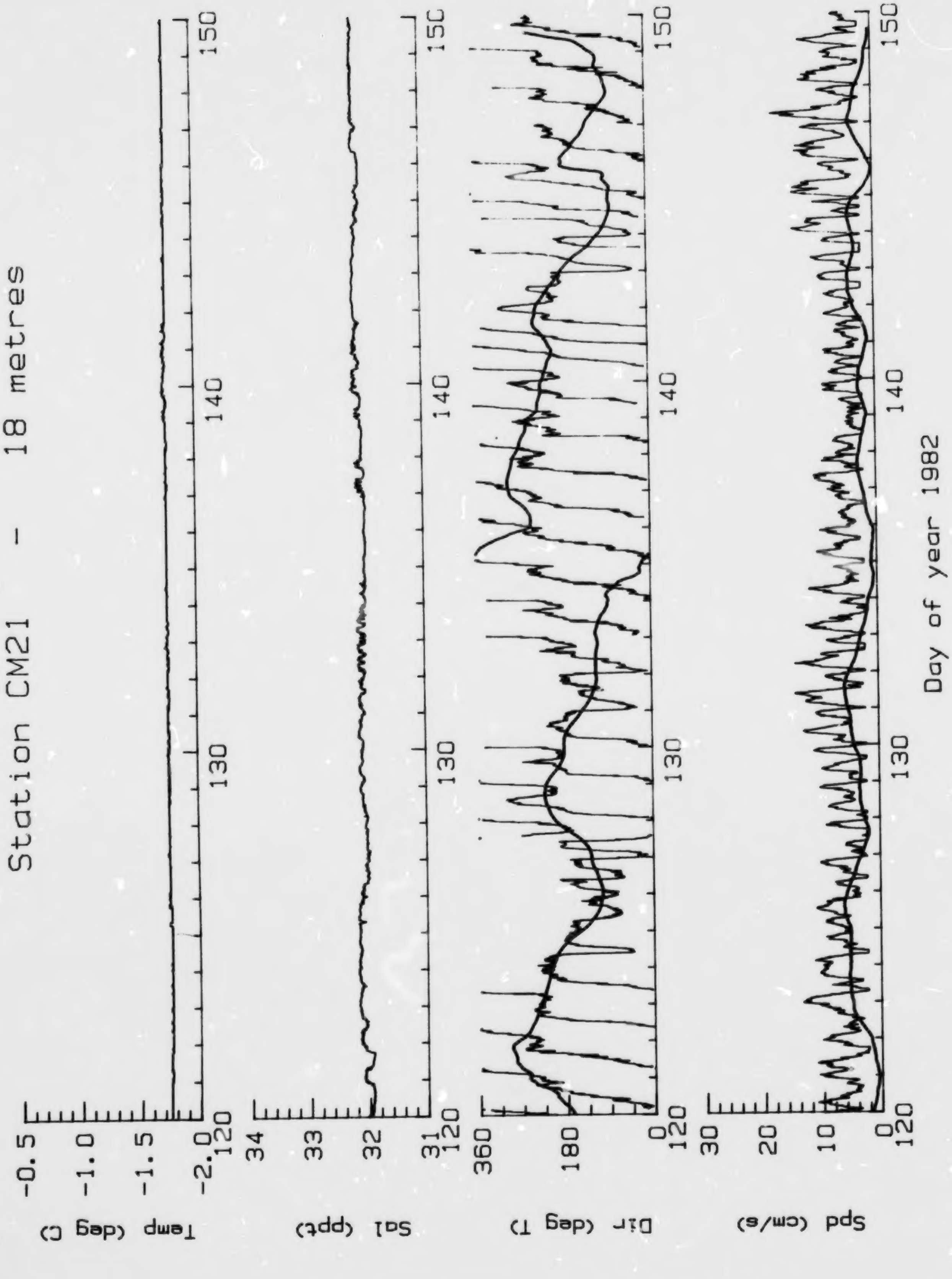

Station CM19 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

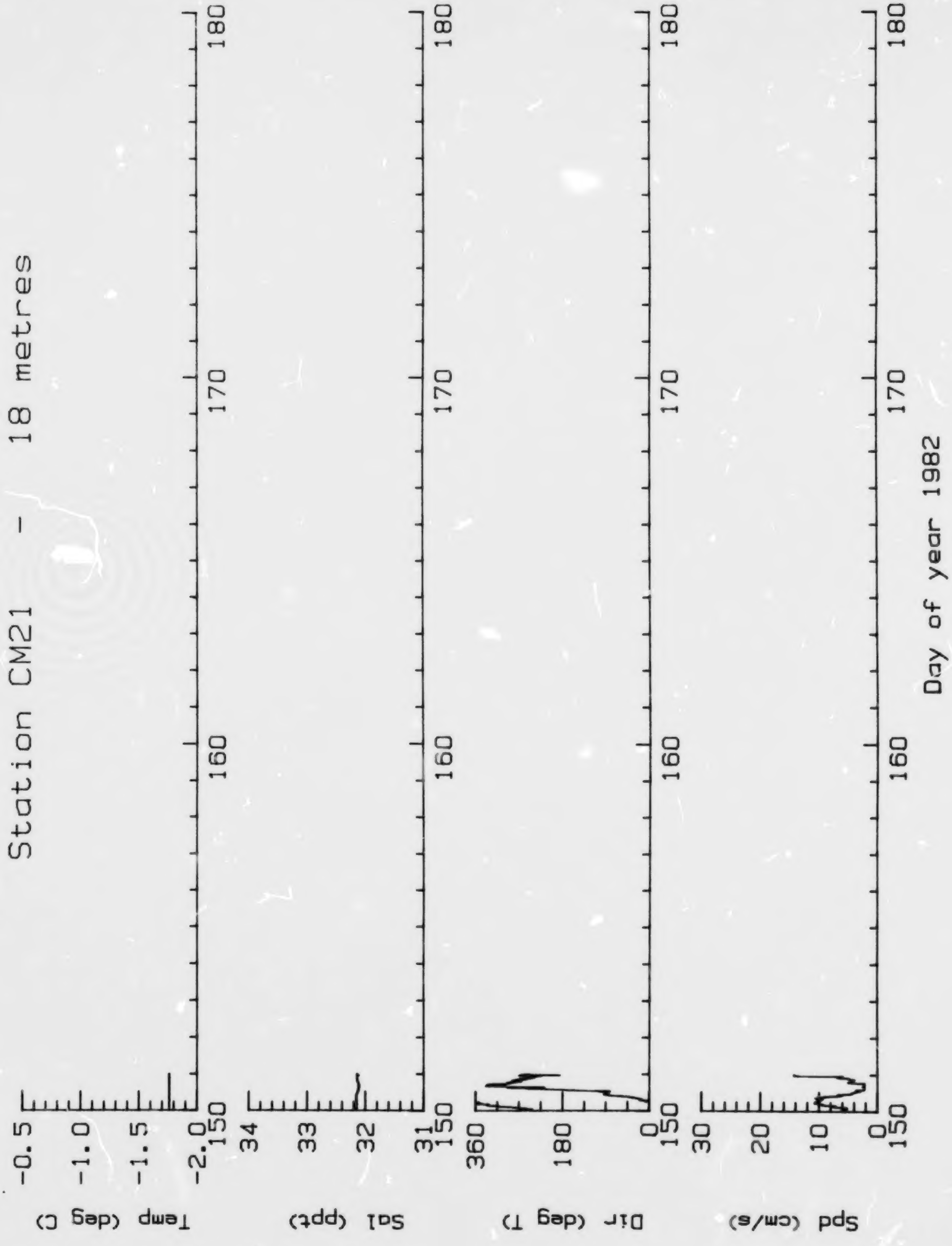

Station CM20 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982


Station CM20 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

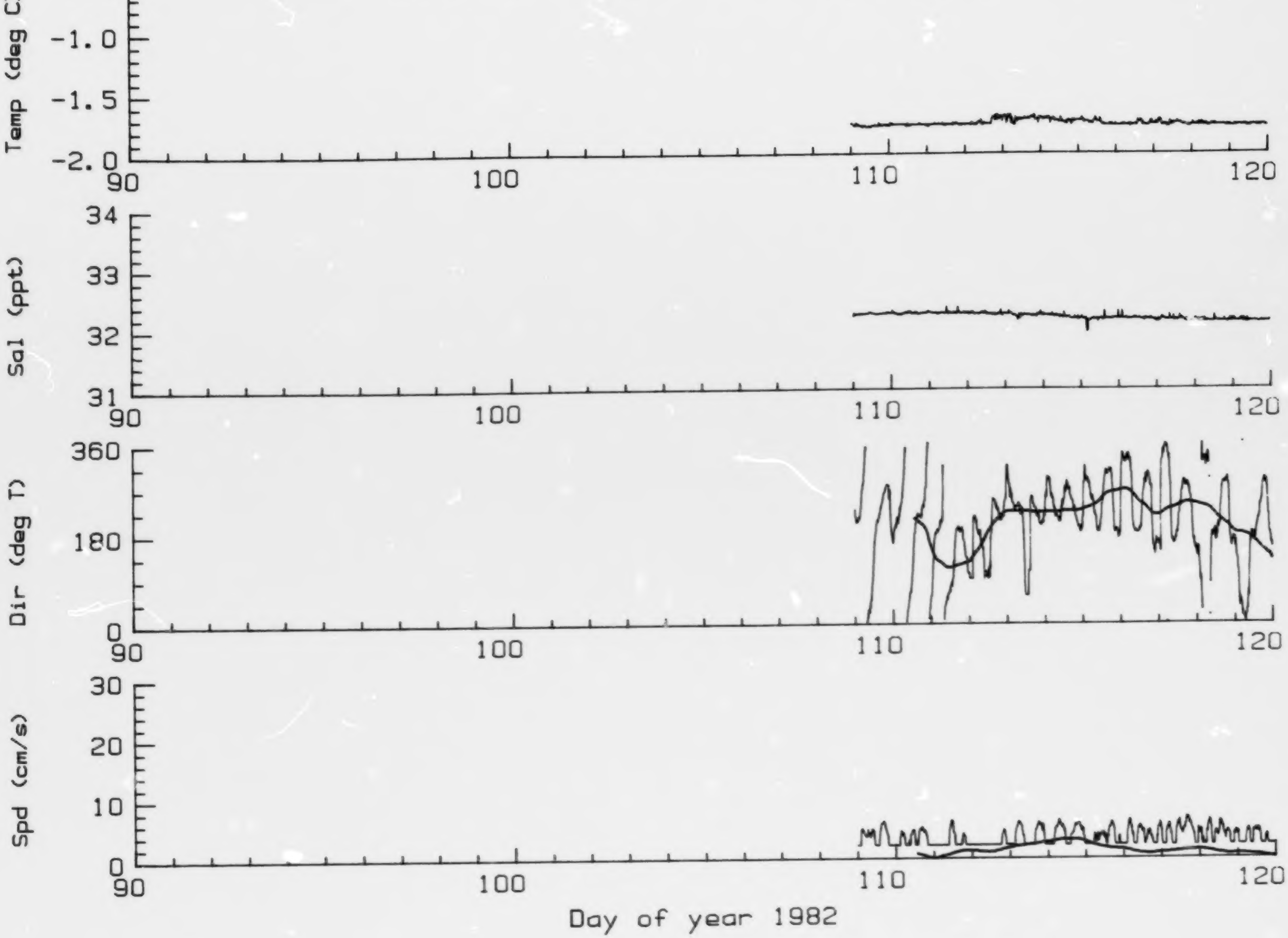

Station CM20 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

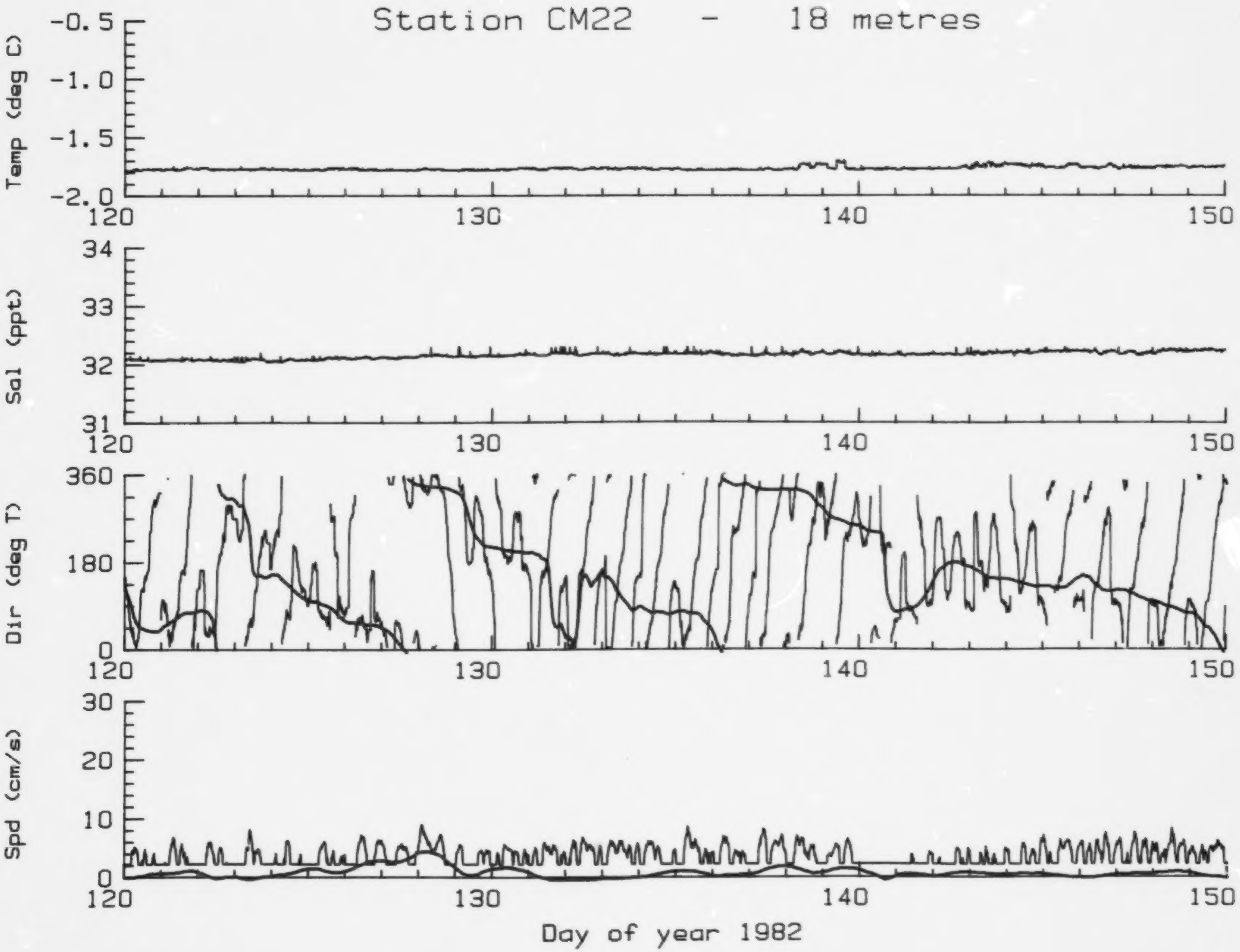

Station CM21 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

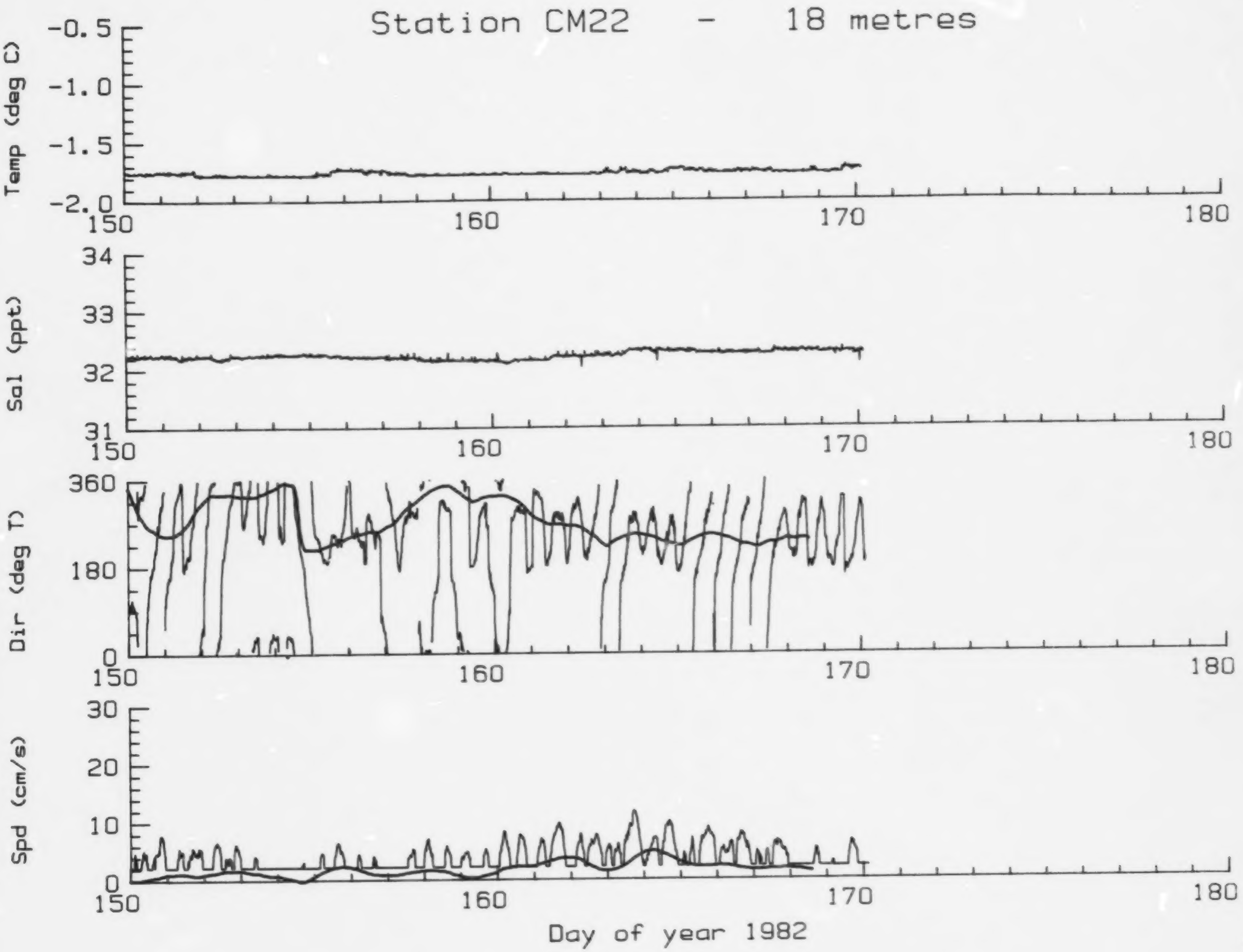

Station CM21 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982


Station CM21 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

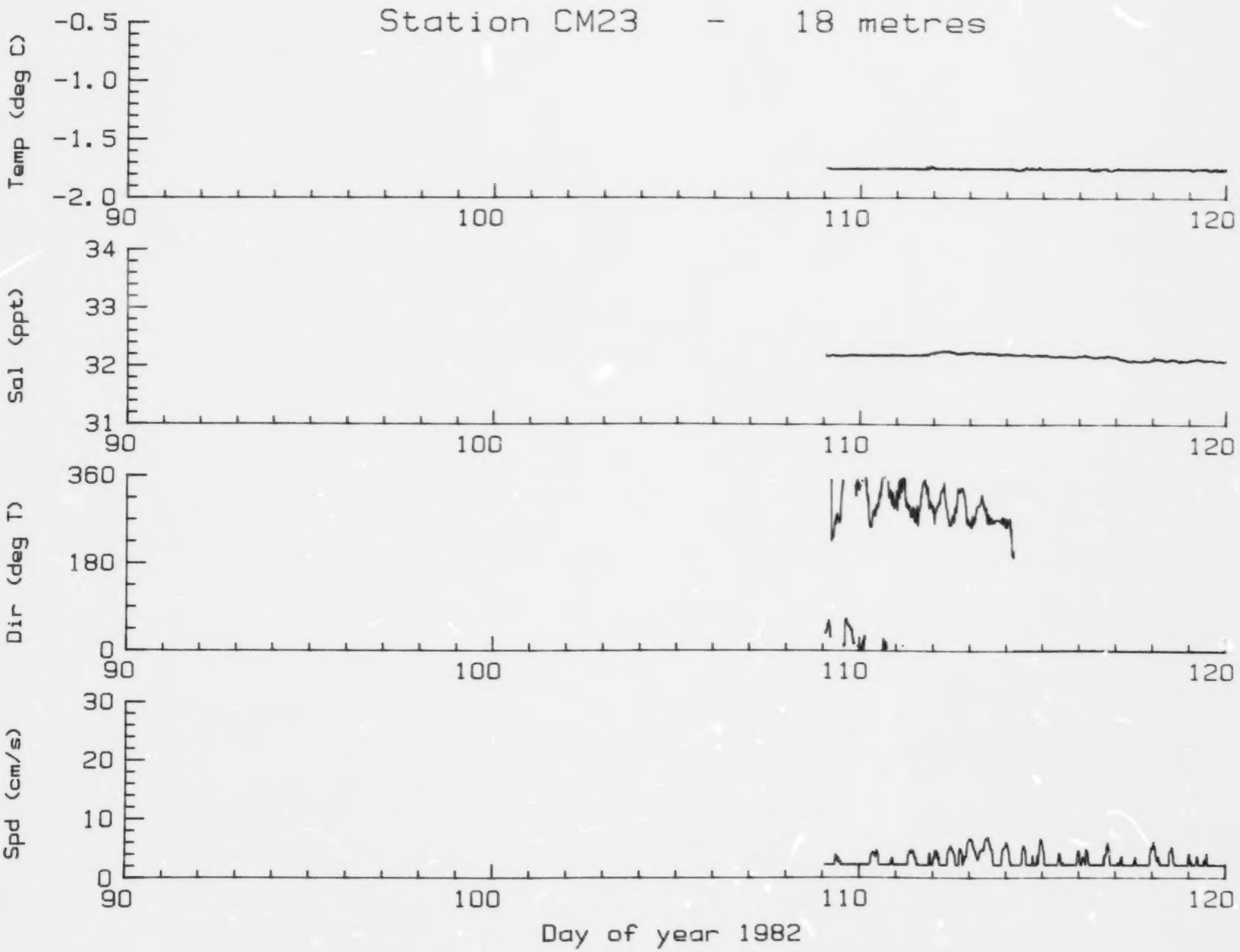
Station CM22 - 18 metres



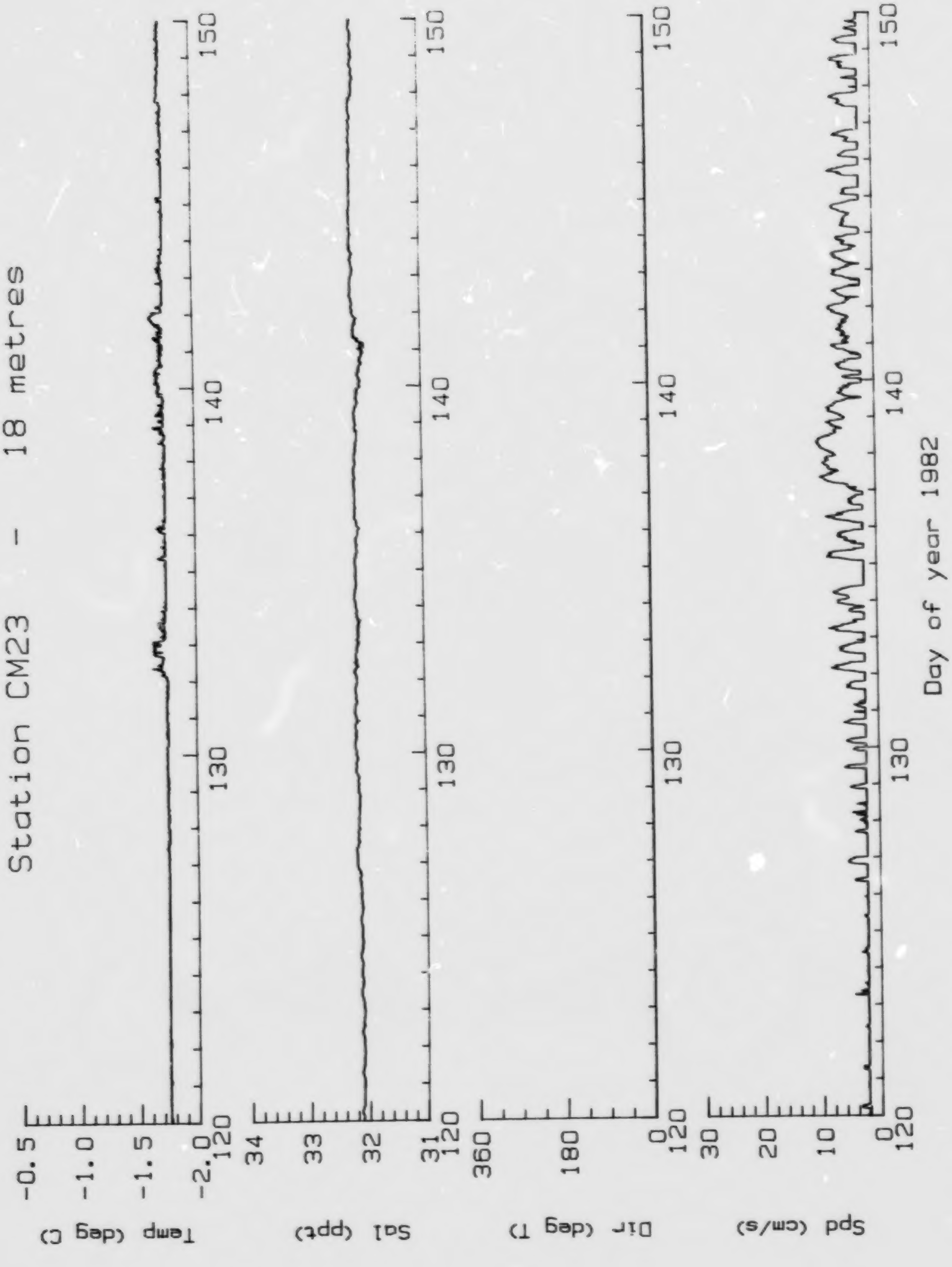

Station CM22 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982



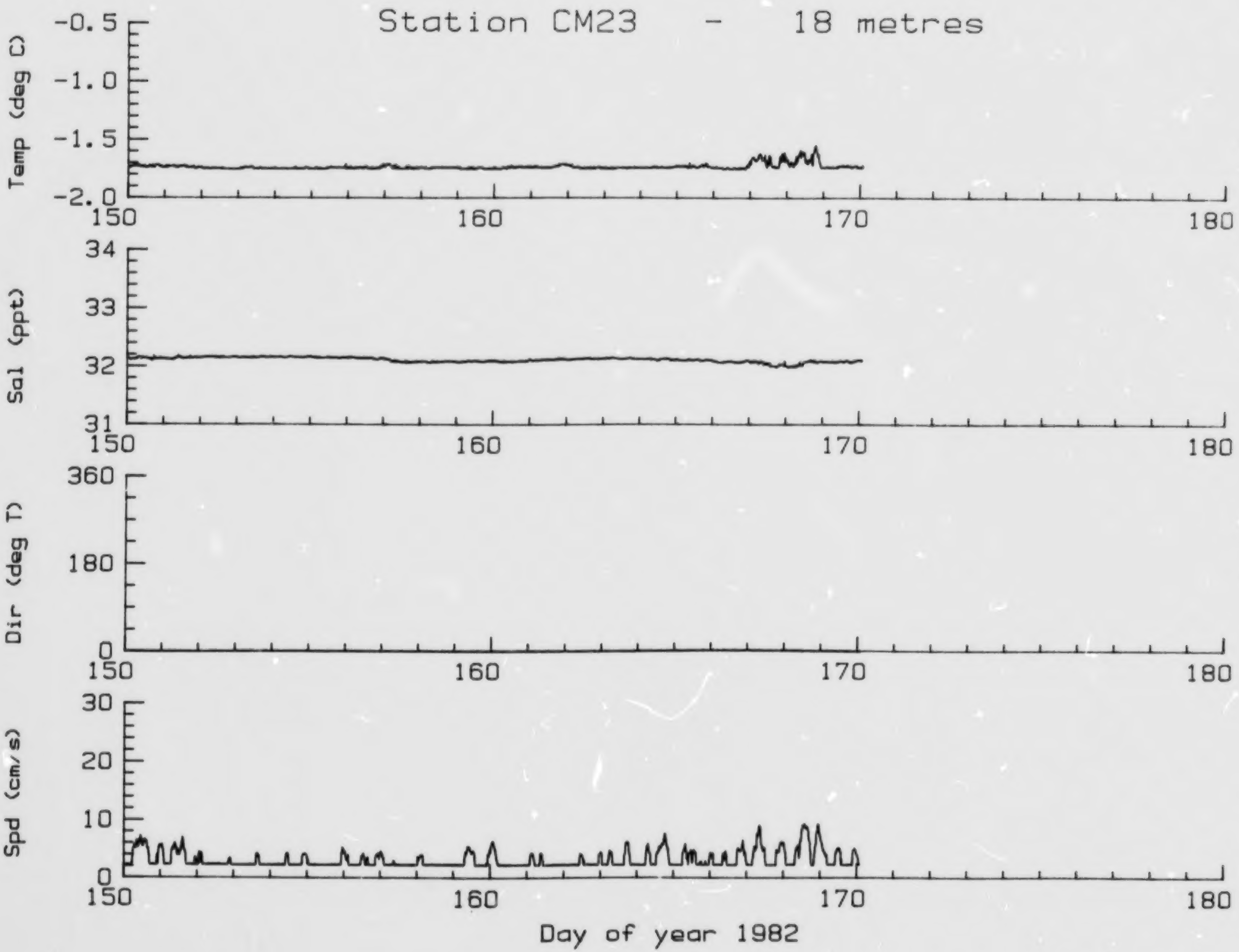
Station CM22 - 18 metres

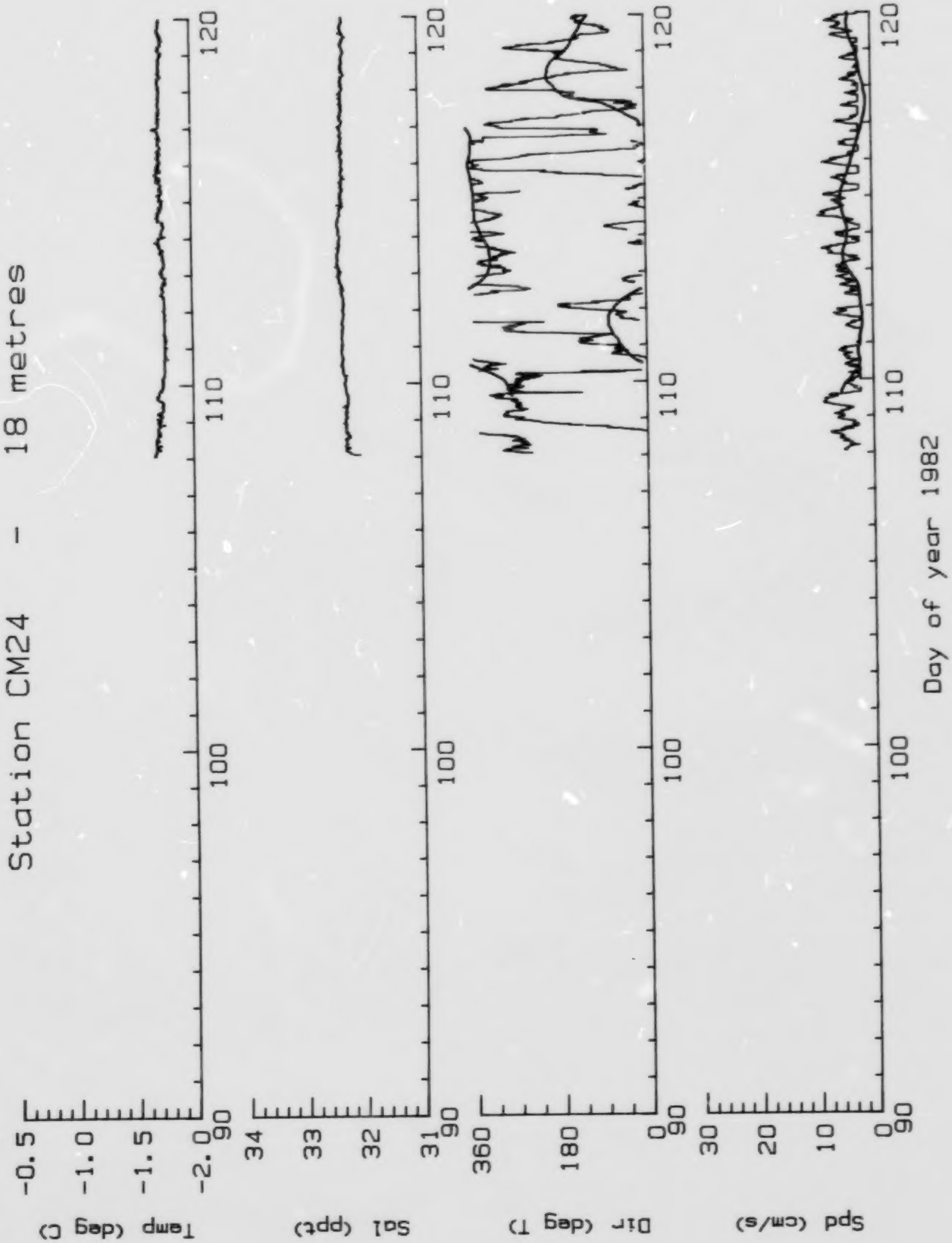


Station CM23 - 18 metres

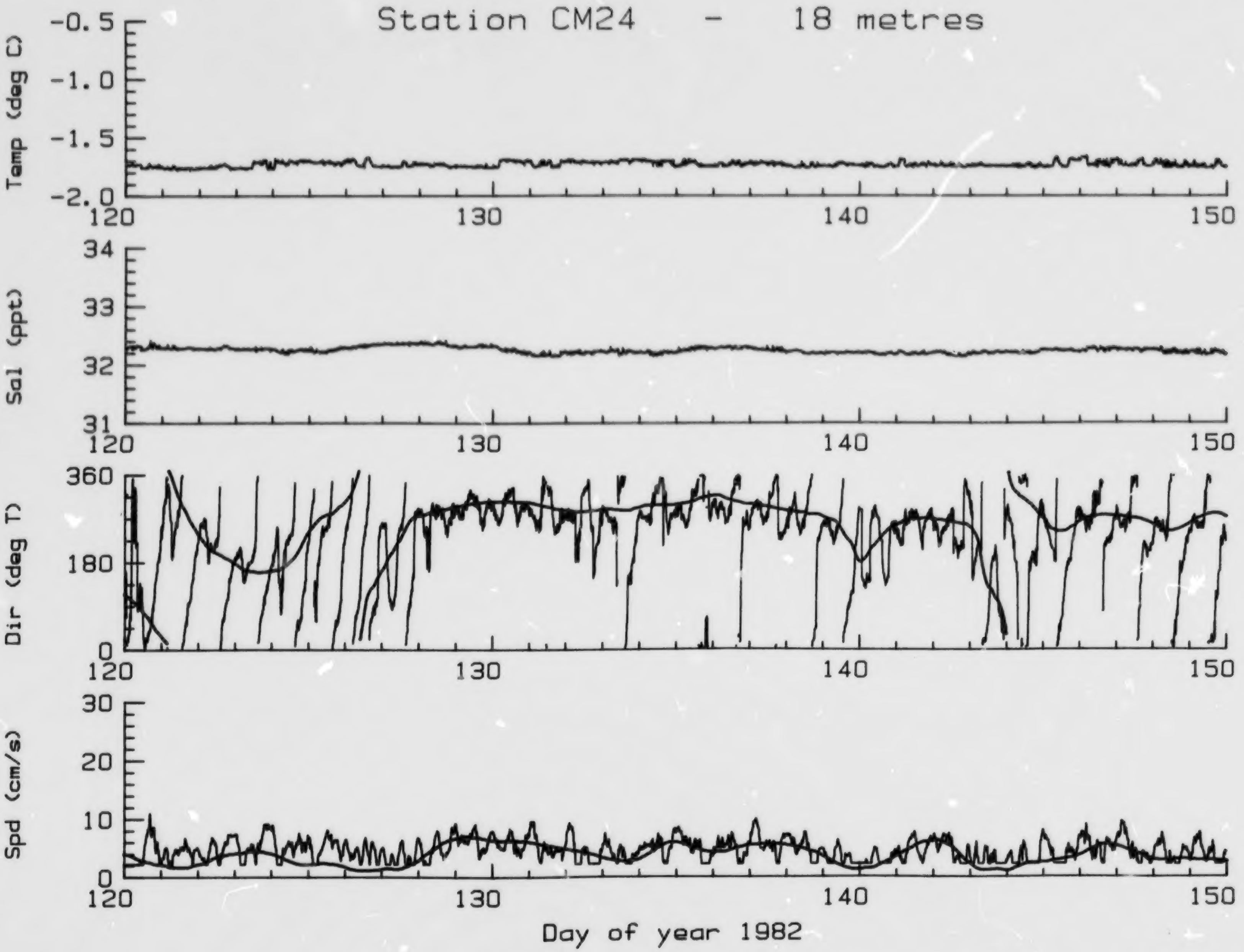


Station CM23 - 18 metres

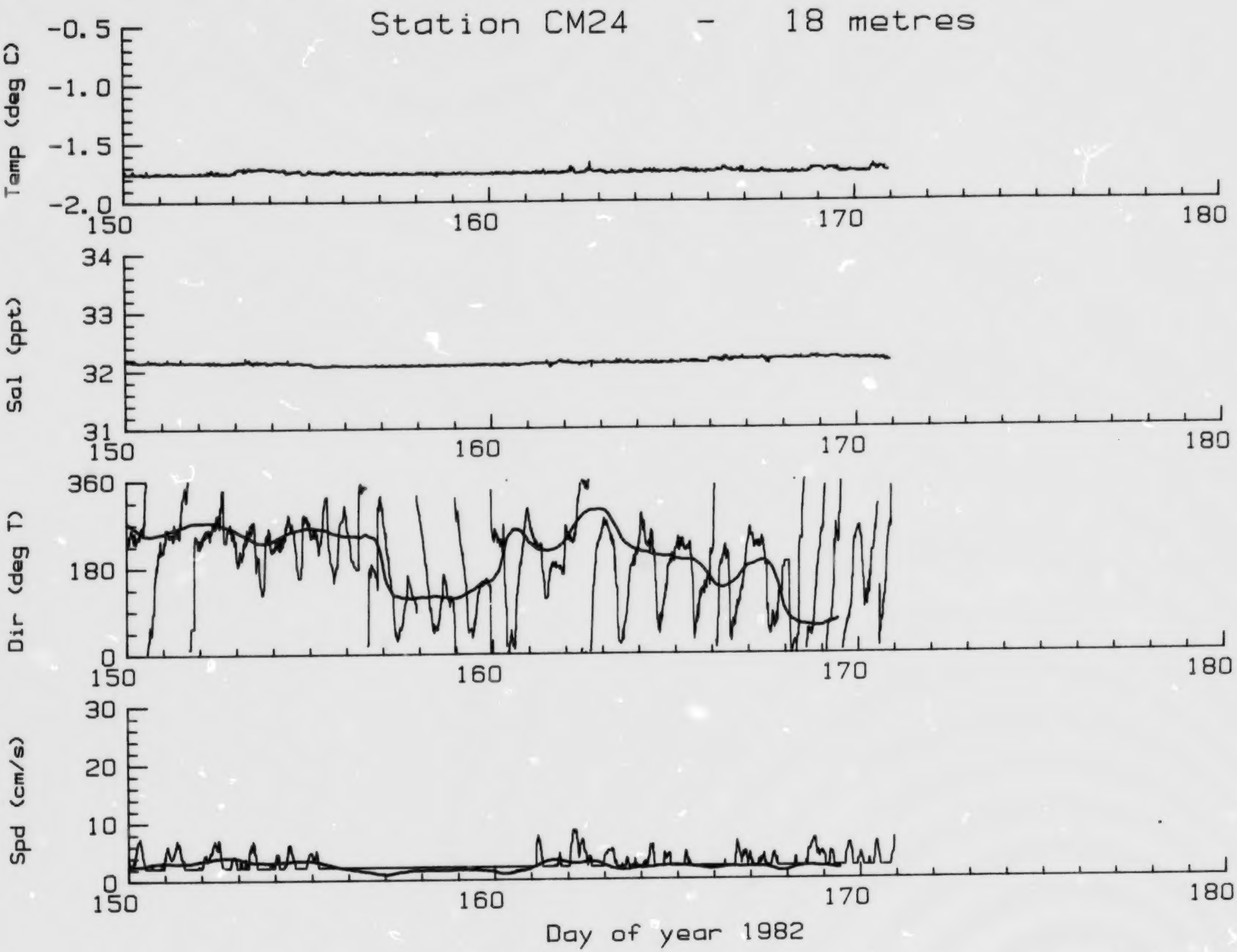

Station CM23 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

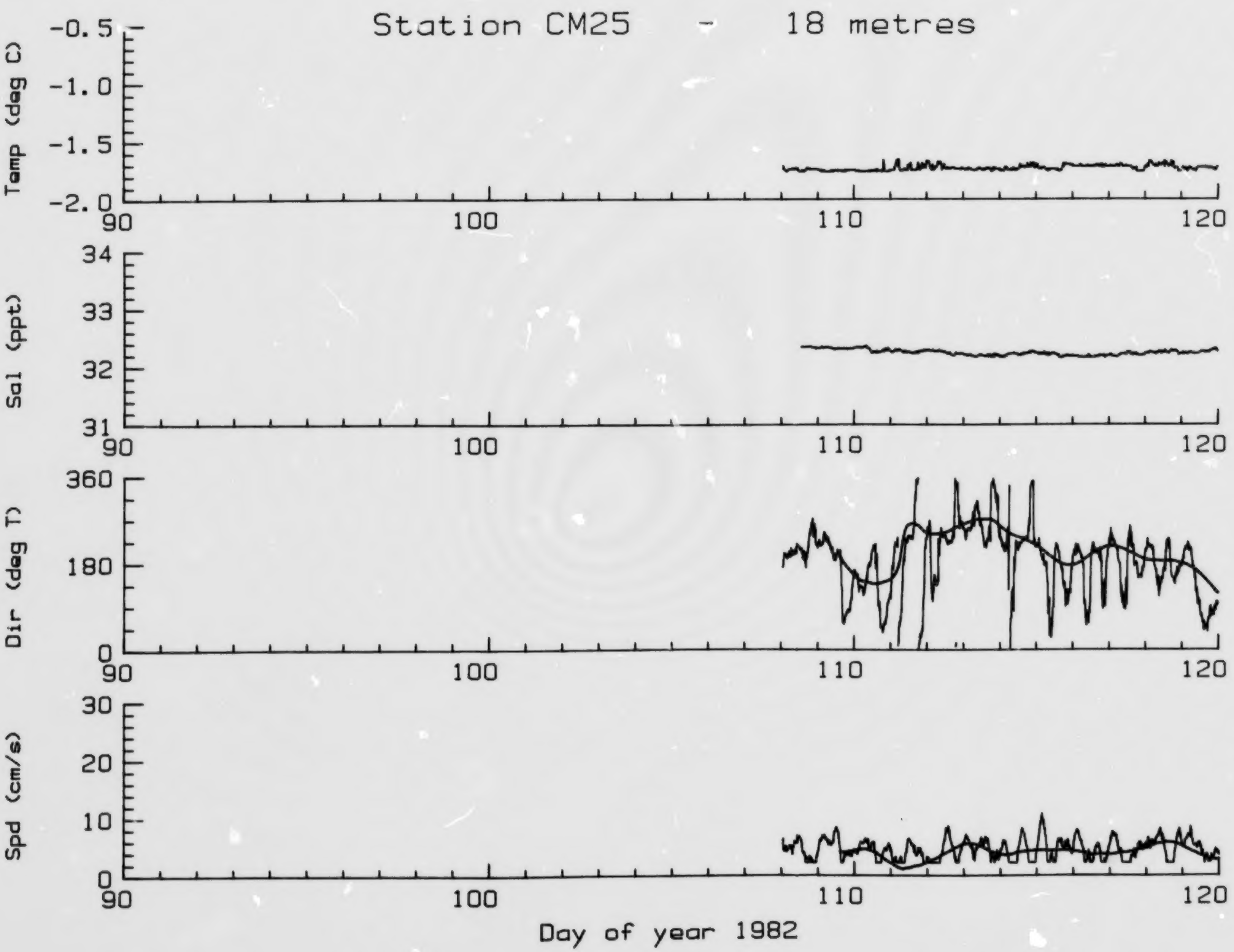


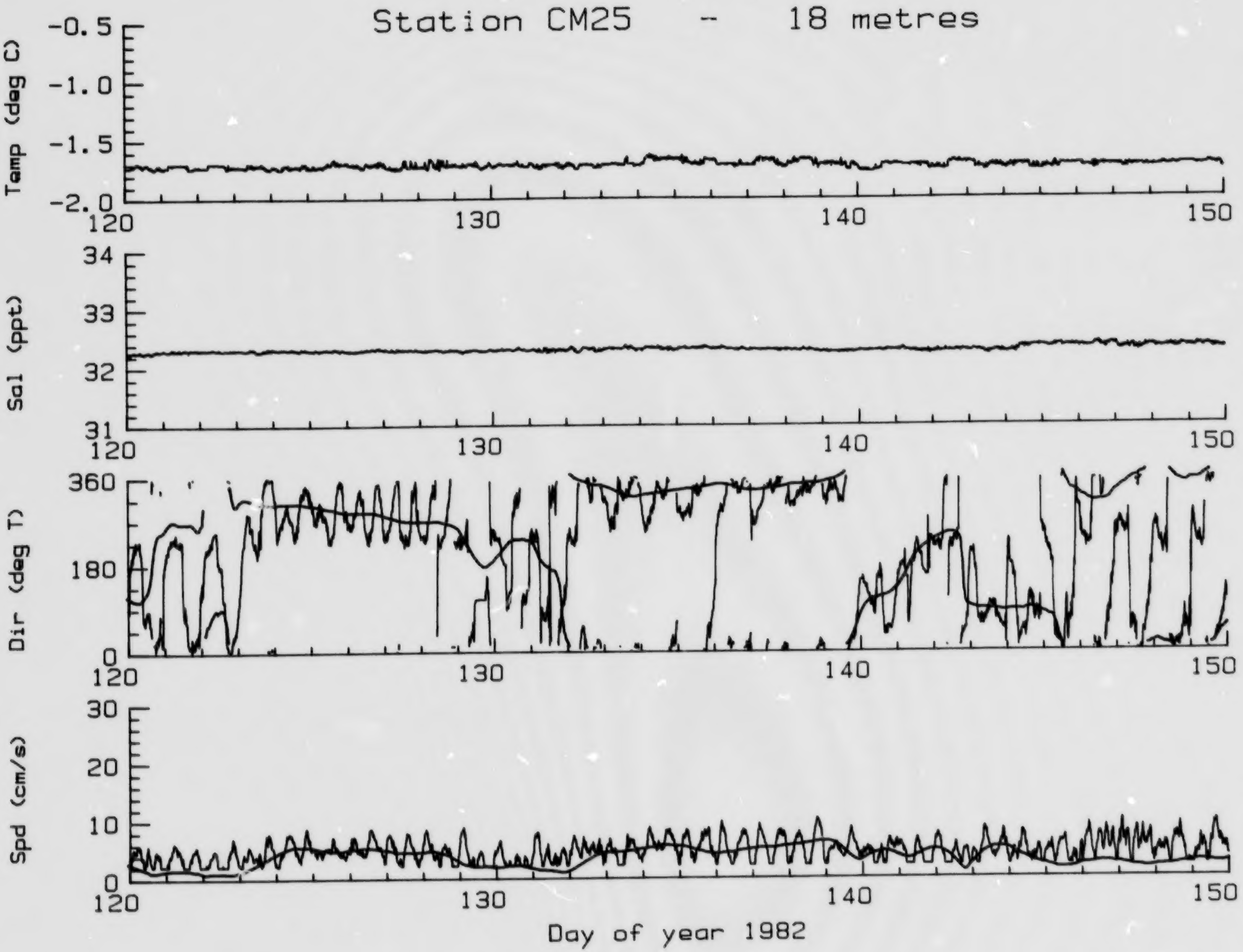
Station CM24 - 18 metres

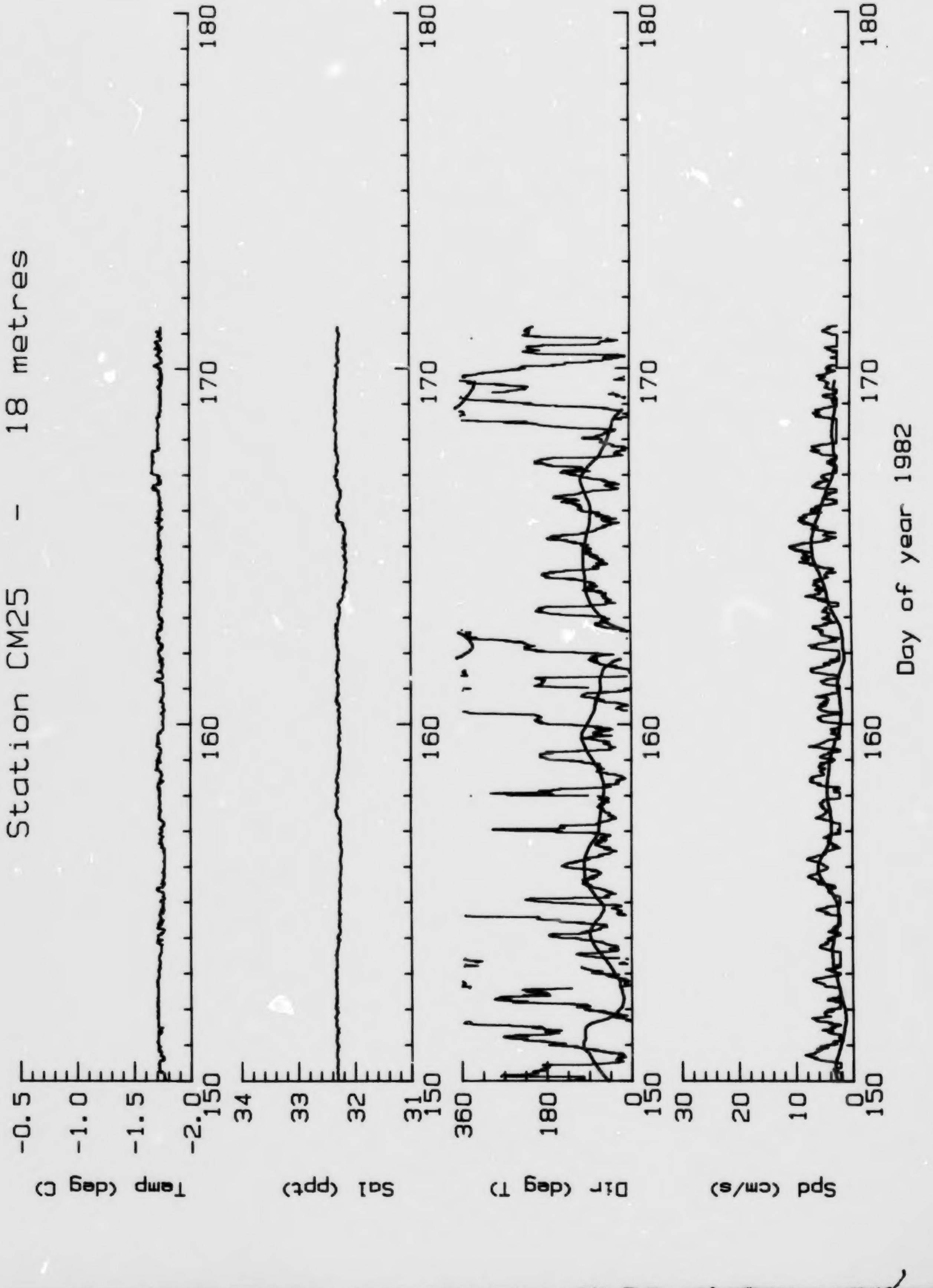


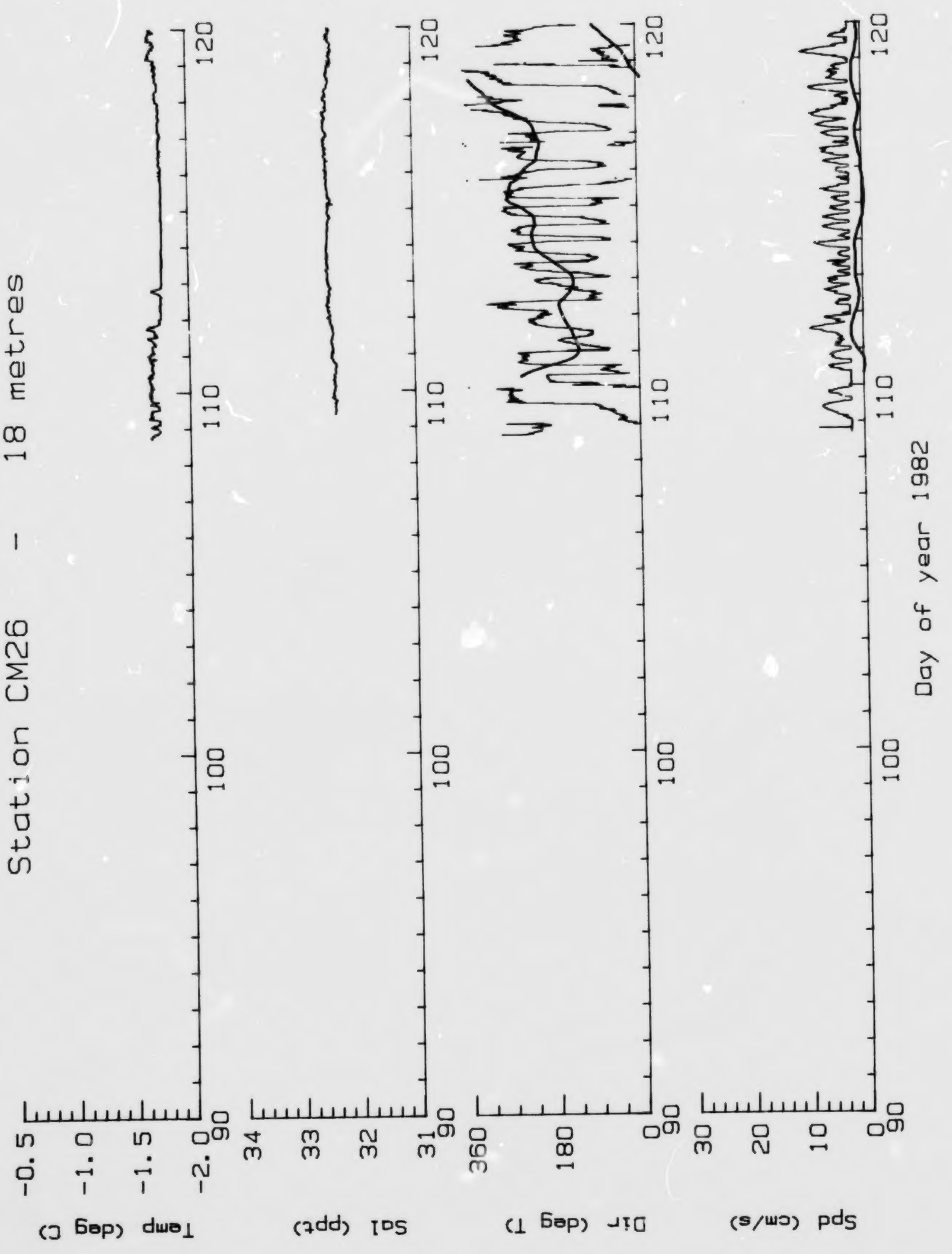
Station CM24 - 18 metres

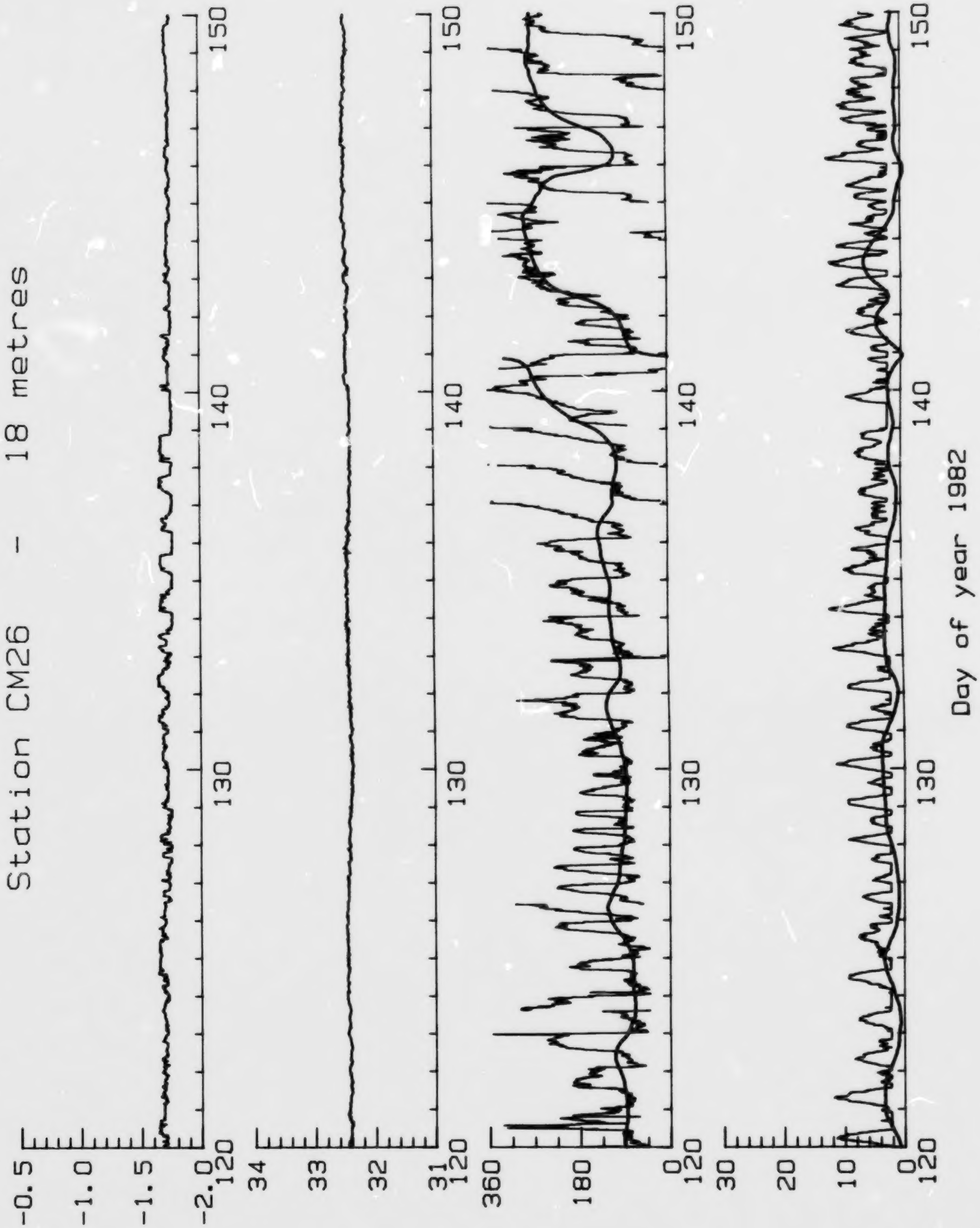

Station CM24 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

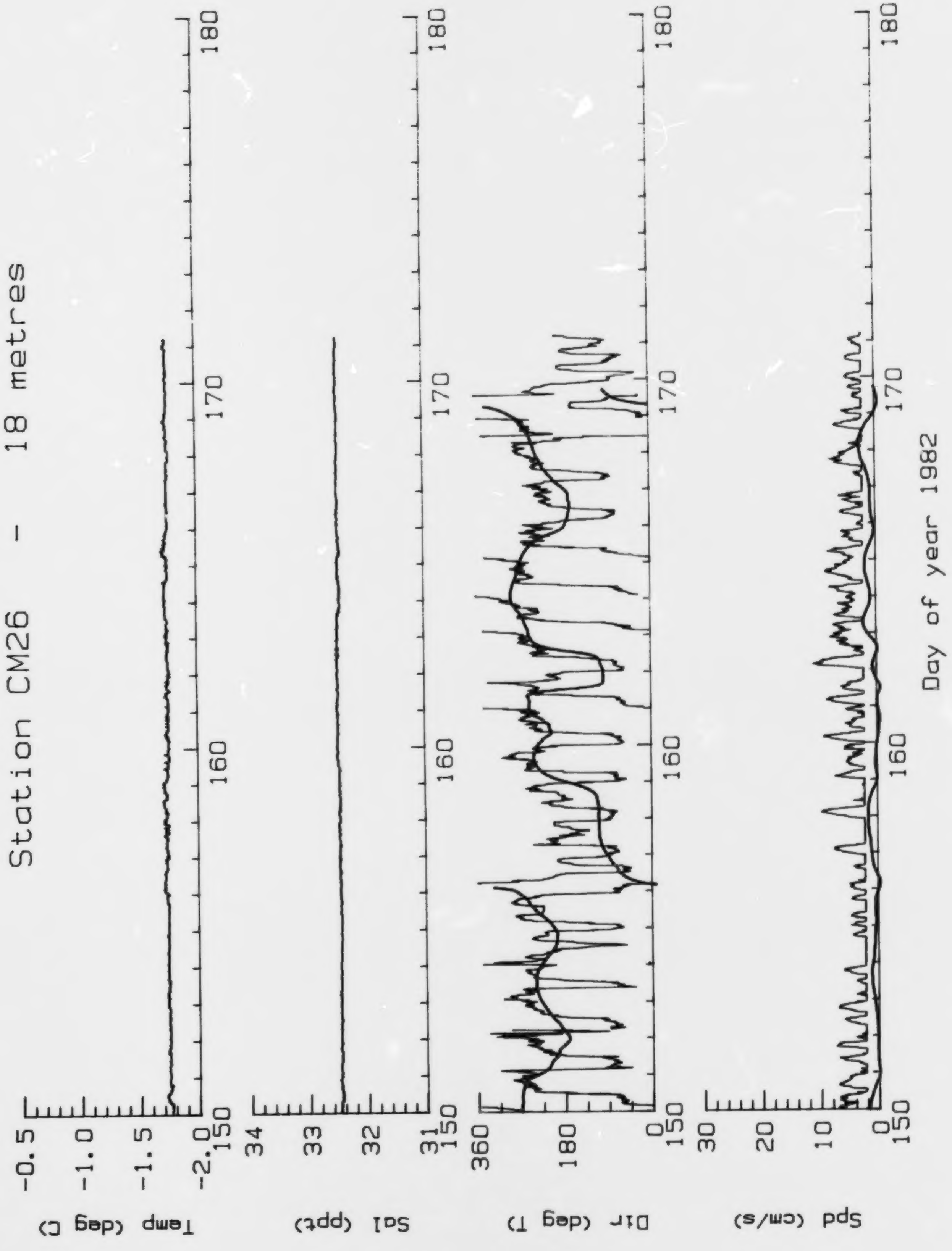

Station CM25 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982

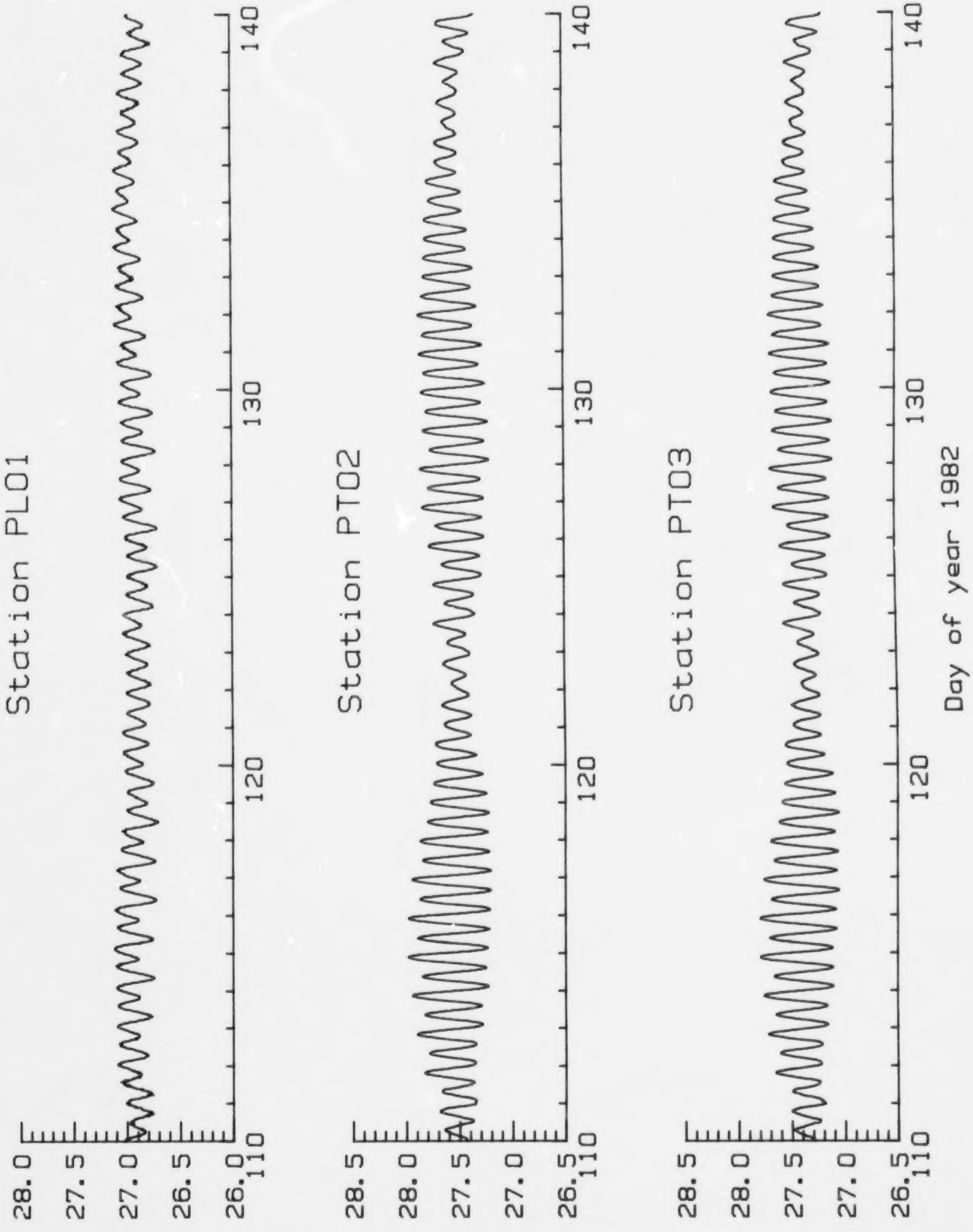

Station CM25 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

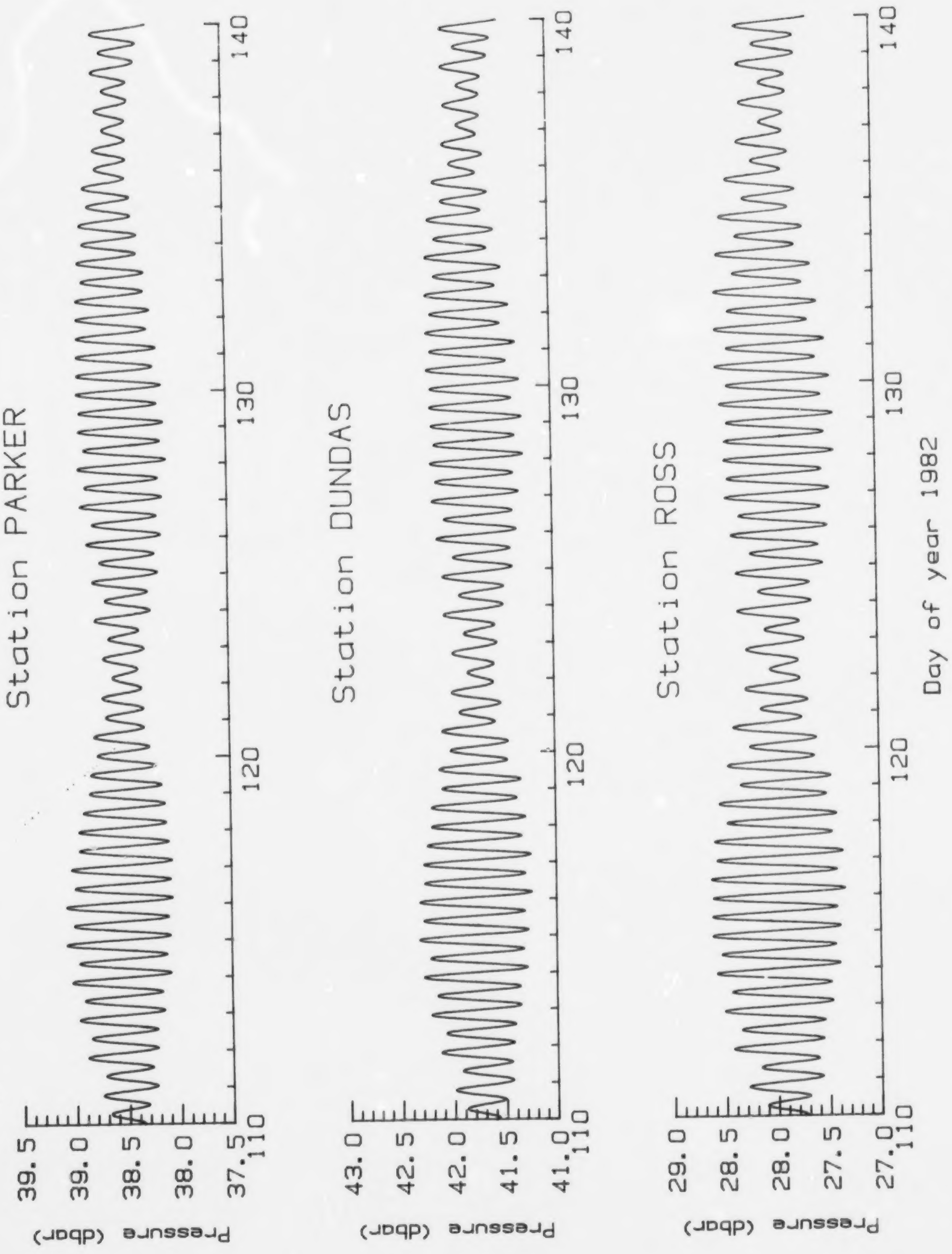

Station CM25 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

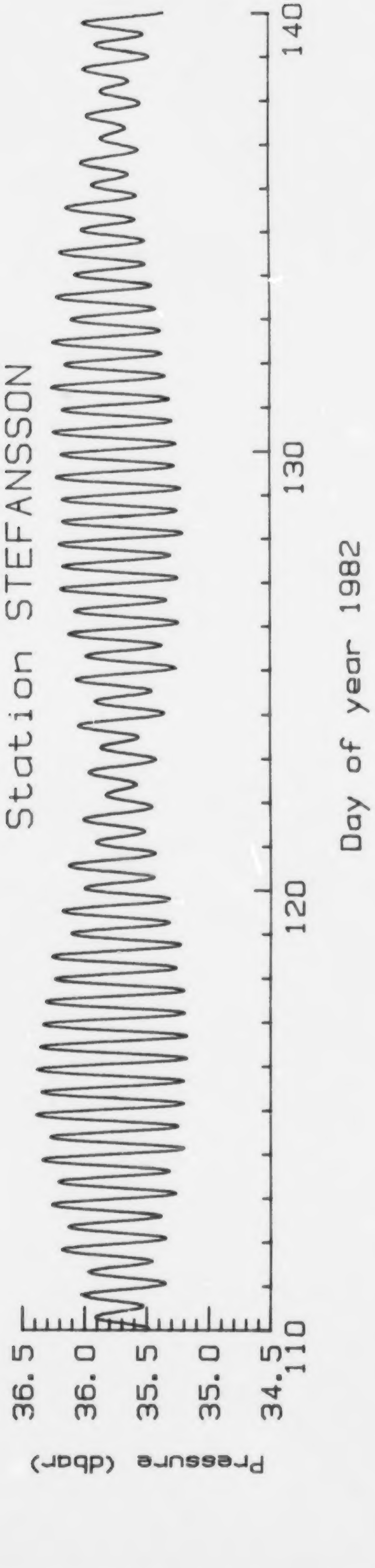

Station CM26 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1982


Station CM26 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1982

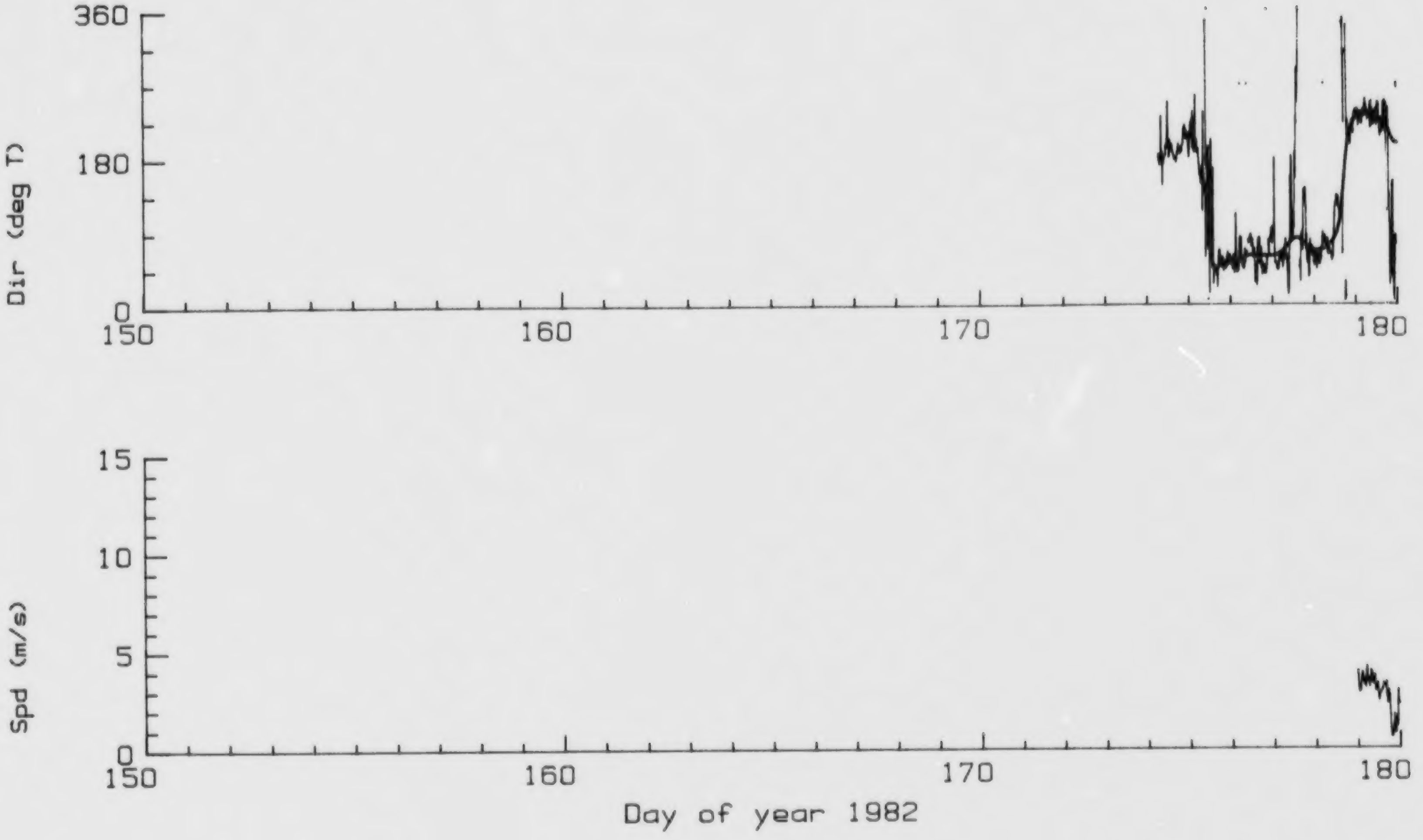

Station CM26 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1982

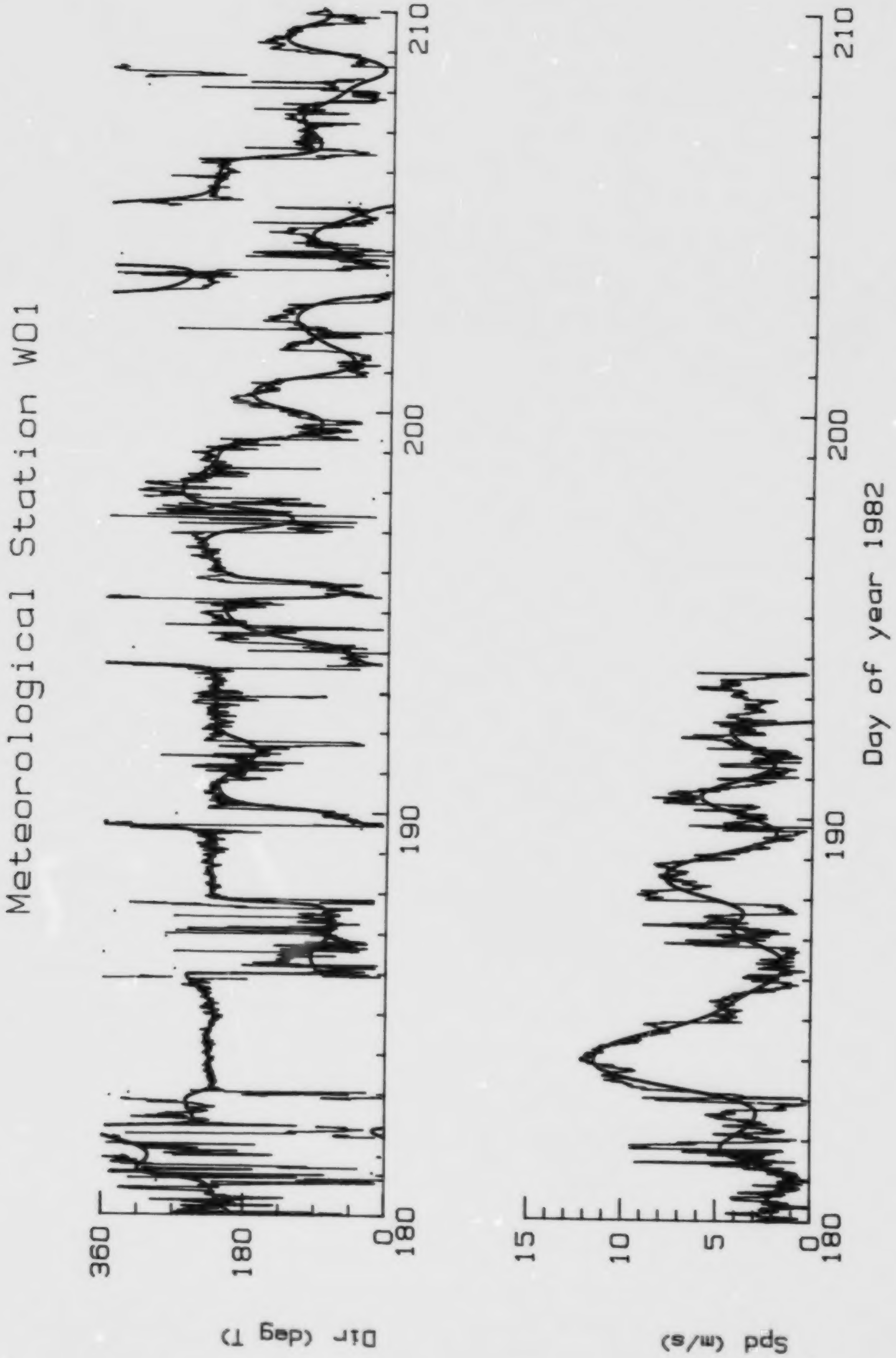

Station PL01
Station PT02
Station PT03
Pressure (dbar)
28.0
27.5
27.0
26.5
26.0
28.5
28.0
27.5
27.0
26.5
110
120
130
140
Day of year 1982

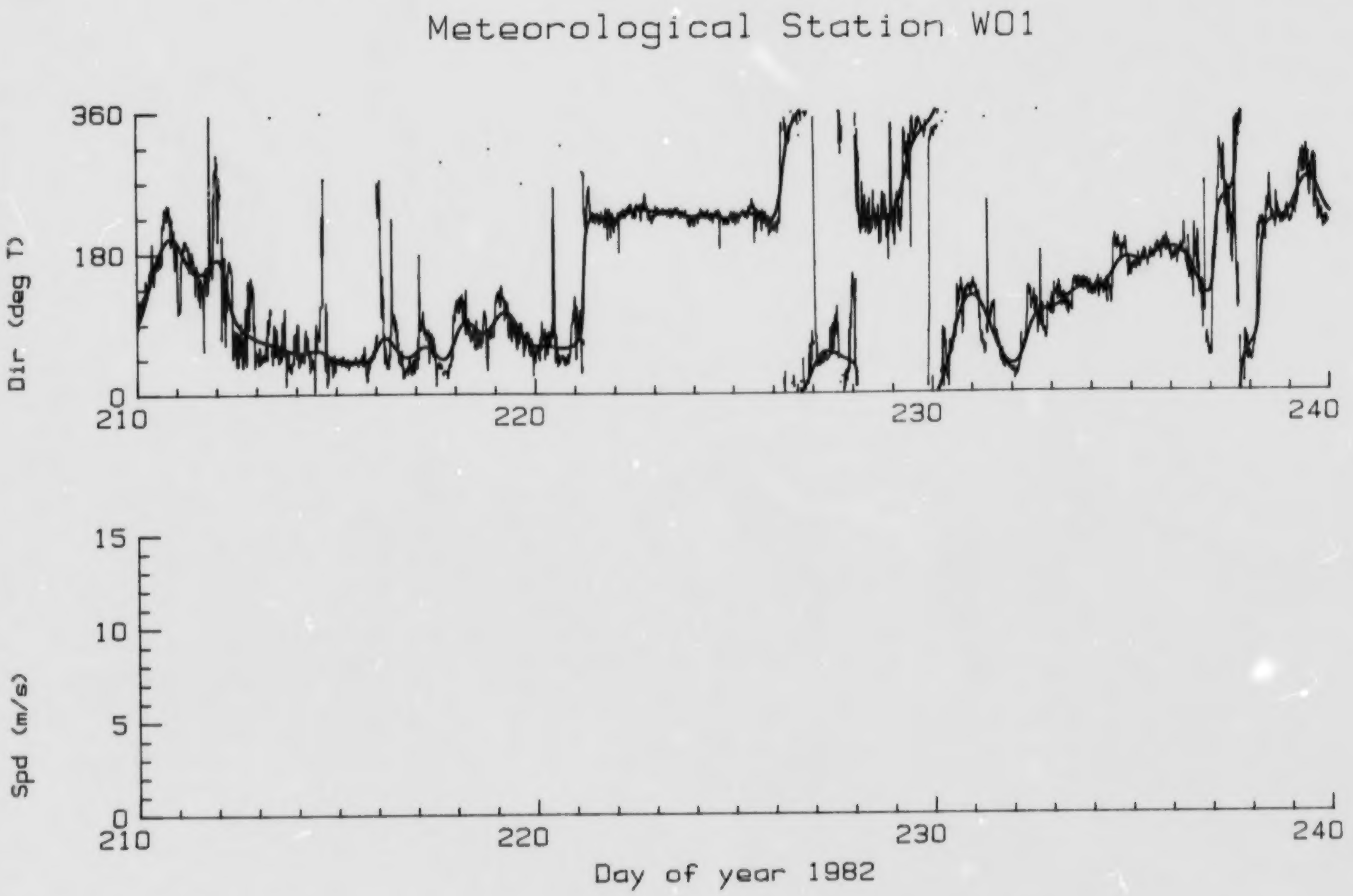

Station PARKER
Station DUNDAS
Station ROSS
Pressure (dbar)
39.5
39.0
38.5
38.0
37.5
43.0
42.5
42.0
41.5
41.0
29.0
28.5
28.0
27.5
27.0
110
120
130
140
Day of year 1982


Station STEFANSSON
Pressure (dbar)
36.5
36.0
35.5
35.0
34.5
110
120
130
140
Day of year 1982

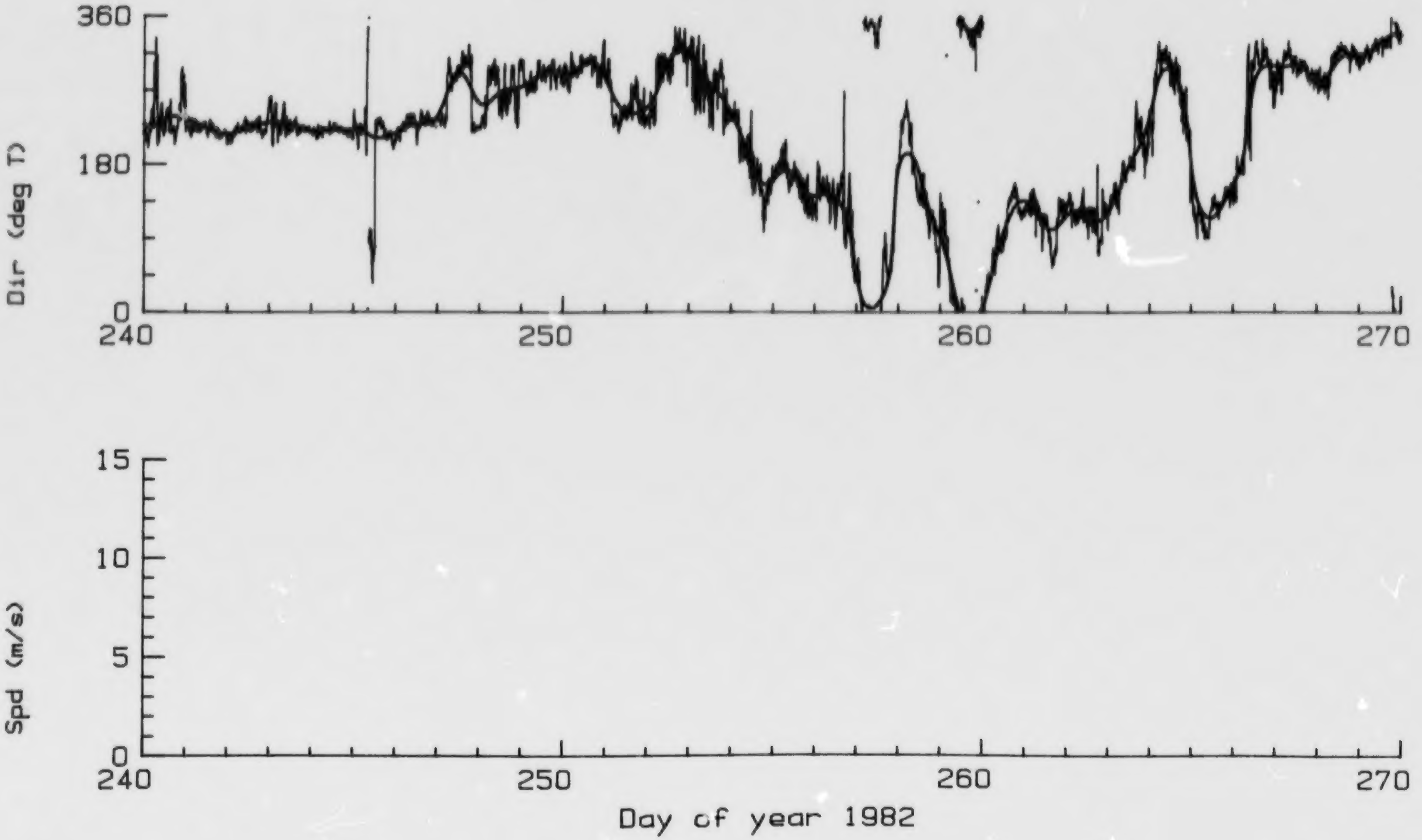
Meteorological Station W01



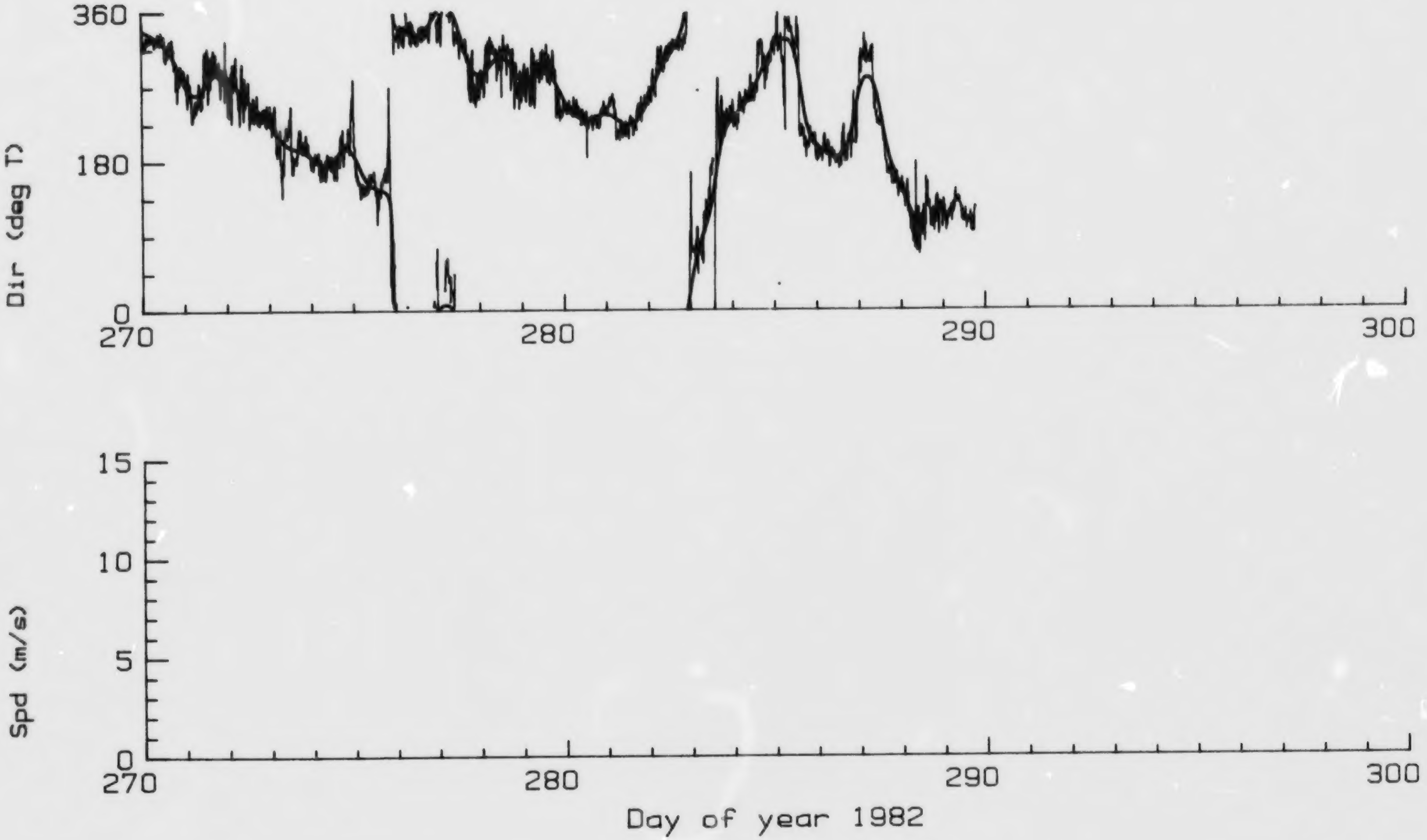

Meteorological Station W01
Dir (deg T)
360
180
0
Spd (m/s)
15
10
5
0
180
190
200
210
Day of year 1982

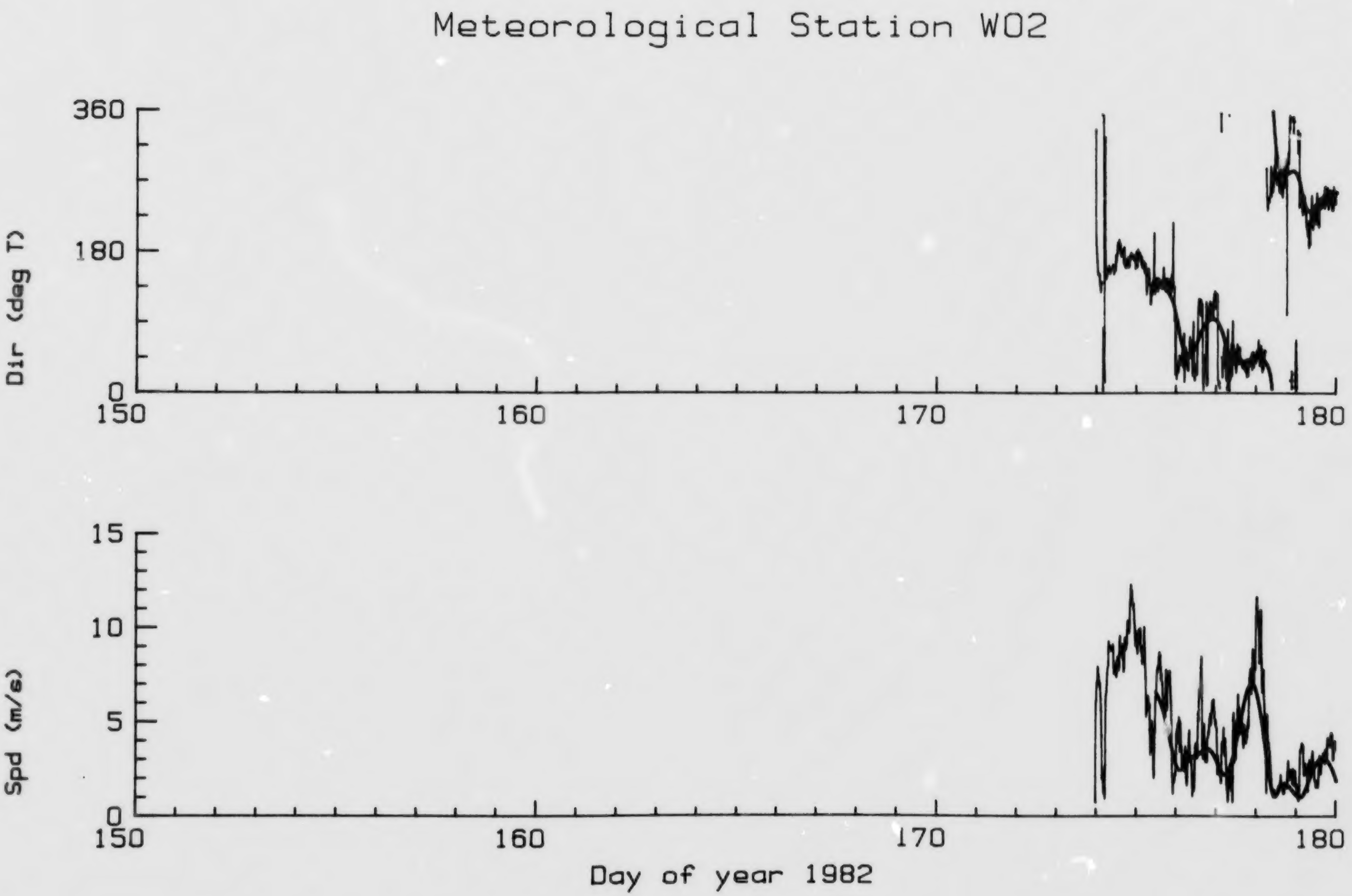

Meteorological Station W01
Dir (deg T)
360
180
0
210
220
230
240
Spd (m/s)
15
10
5
0
210
220
230
240
Day of year 1982

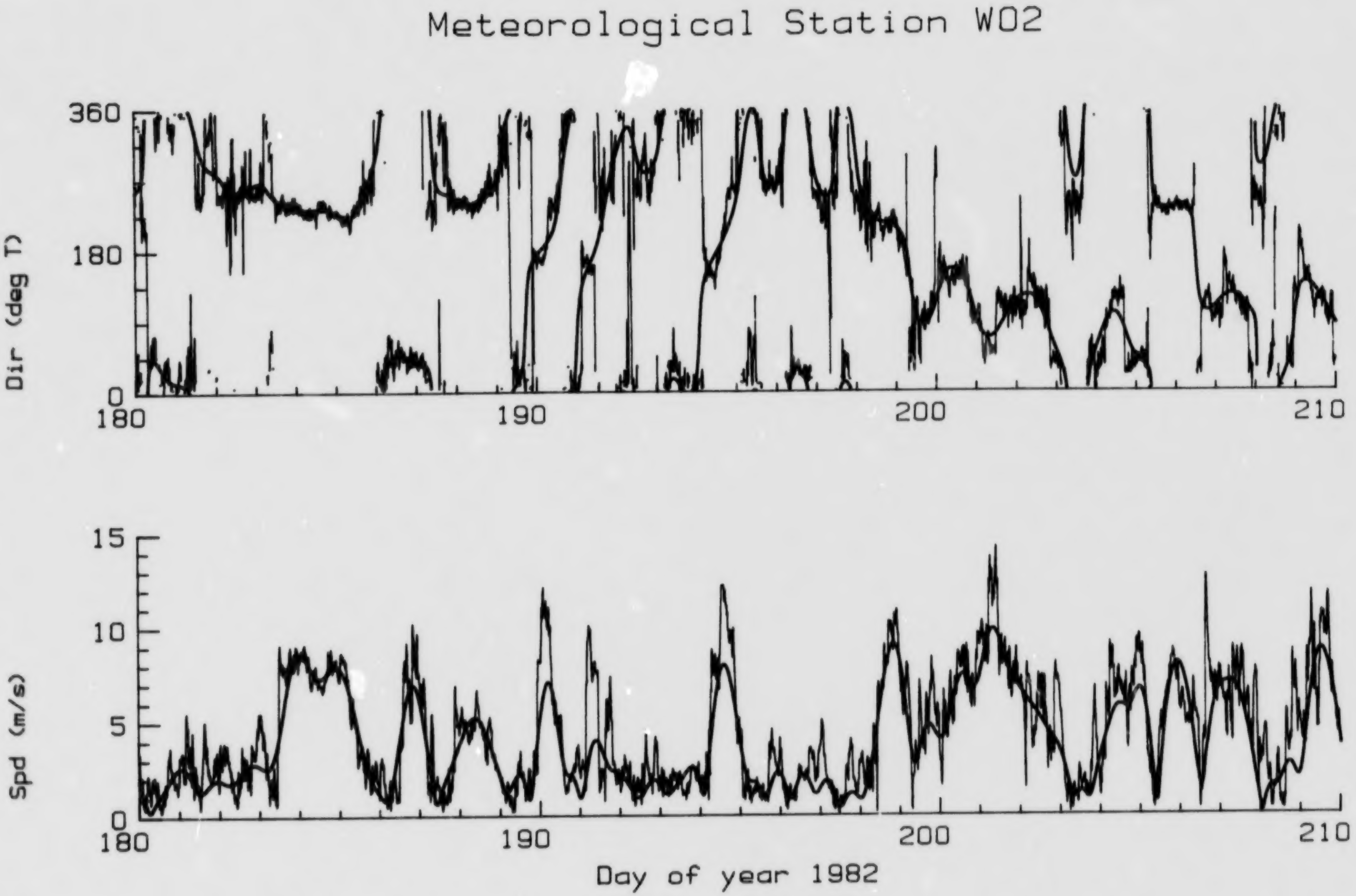
Meteorological Station W01

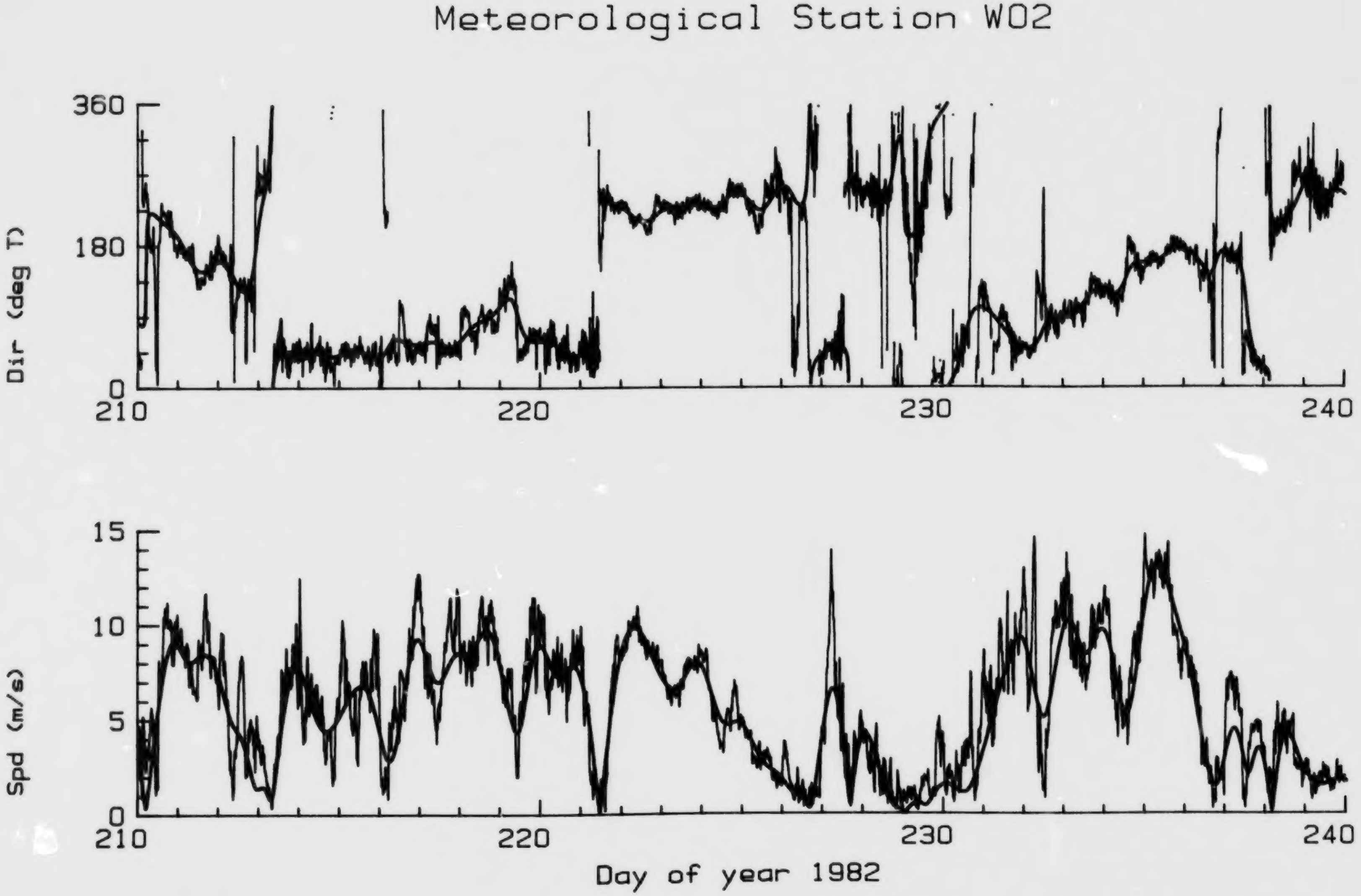


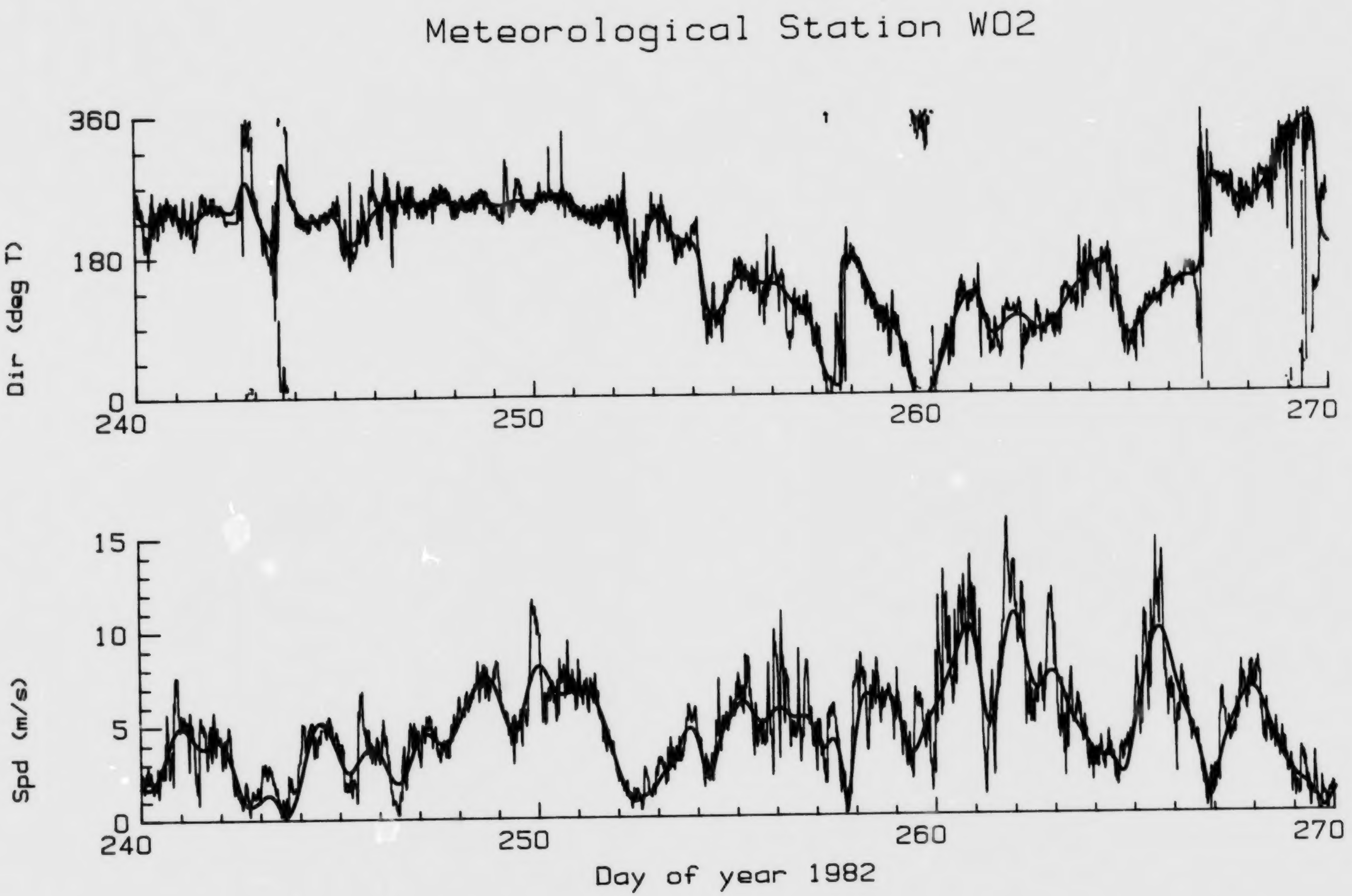
Meteorological Station W01



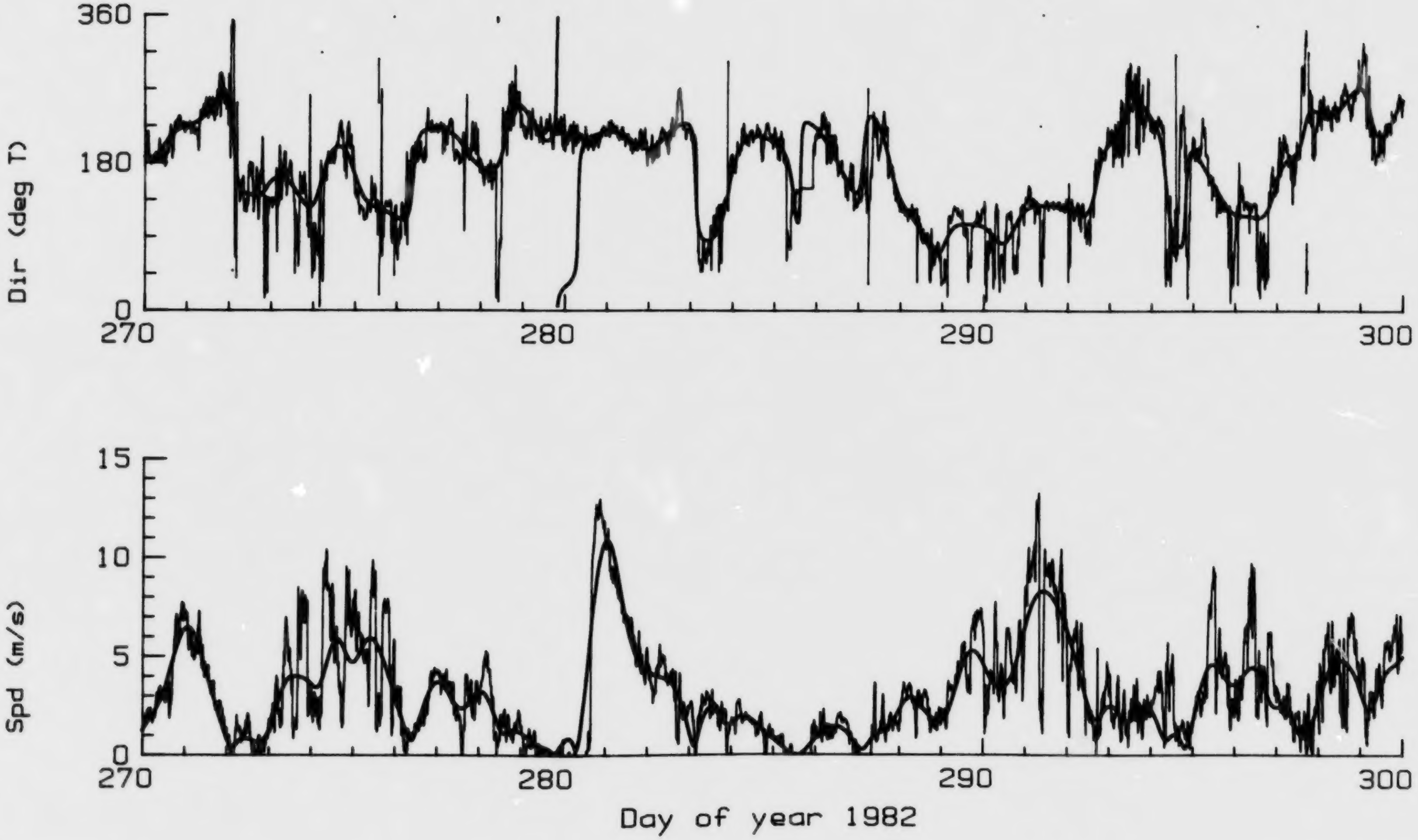

Meteorological Station W02
Dir (deg T)
360
180
0
150
160
170
180
Spd (m/s)
15
10
5
0
150
160
170
180
Day of year 1982


Meteorological Station W02
Dir (deg T)
360
180
0
180
190
200
210
Spd (m/s)
15
10
5
0
180
190
200
210
Day of year 1982


Meteorological Station W02
Dir (deg T)
360
180
0
210
220
230
240
Spd (m/s)
15
10
5
0
210
220
230
240
Day of year 1982



Meteorological Station W02



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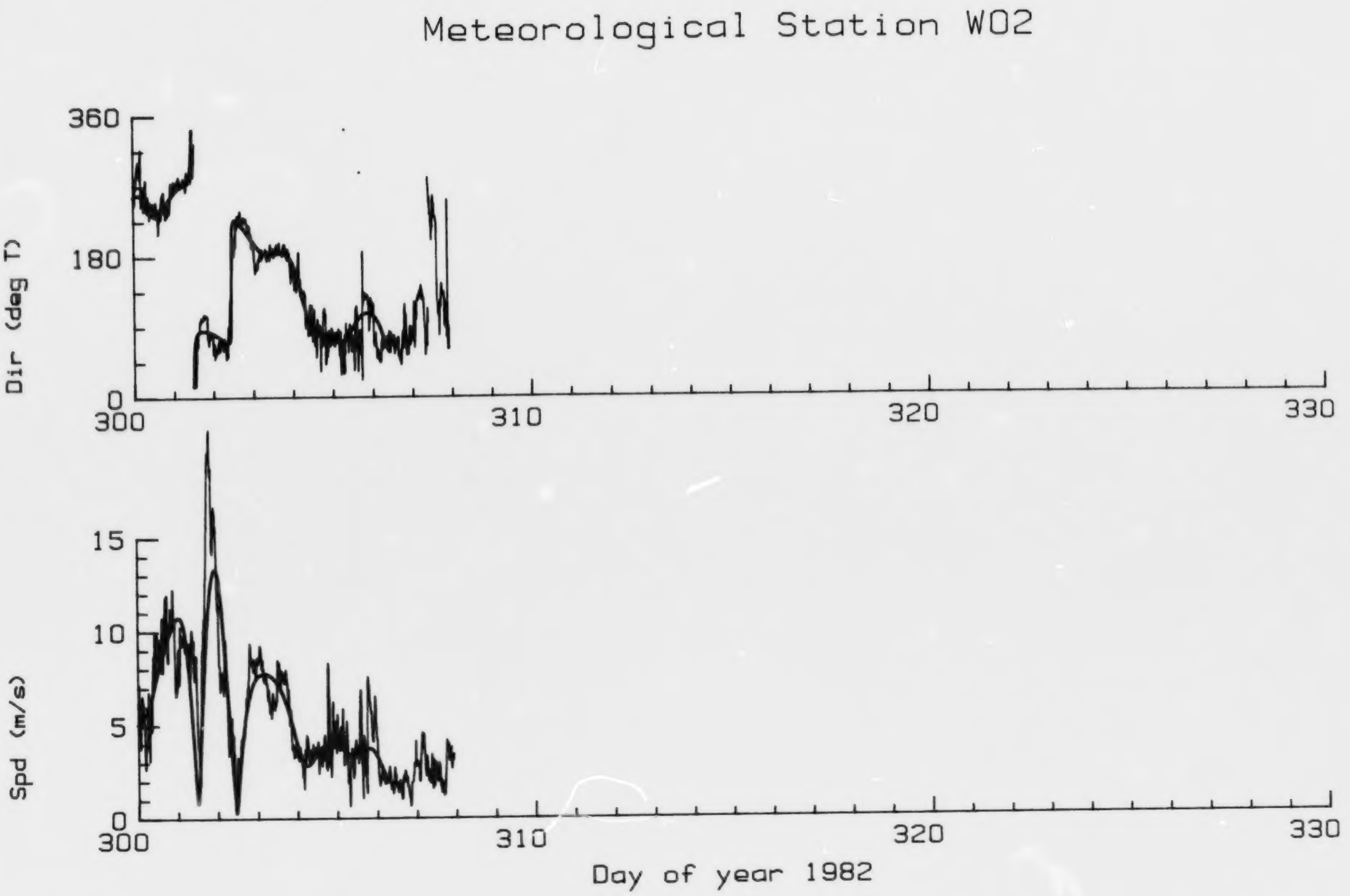
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0
300
310
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330
Spd (m/s)
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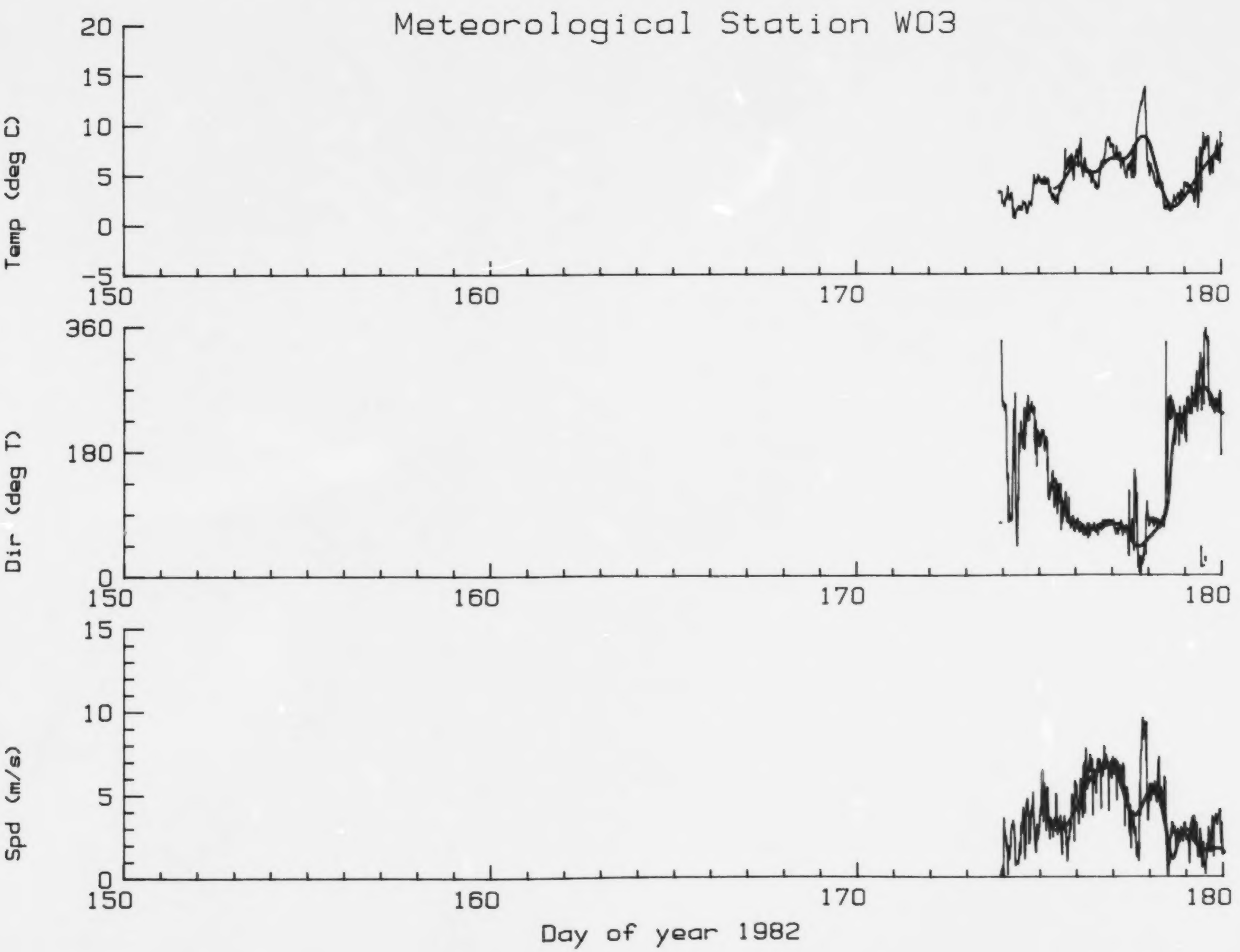
0
300
310
320
330
Day of year 1982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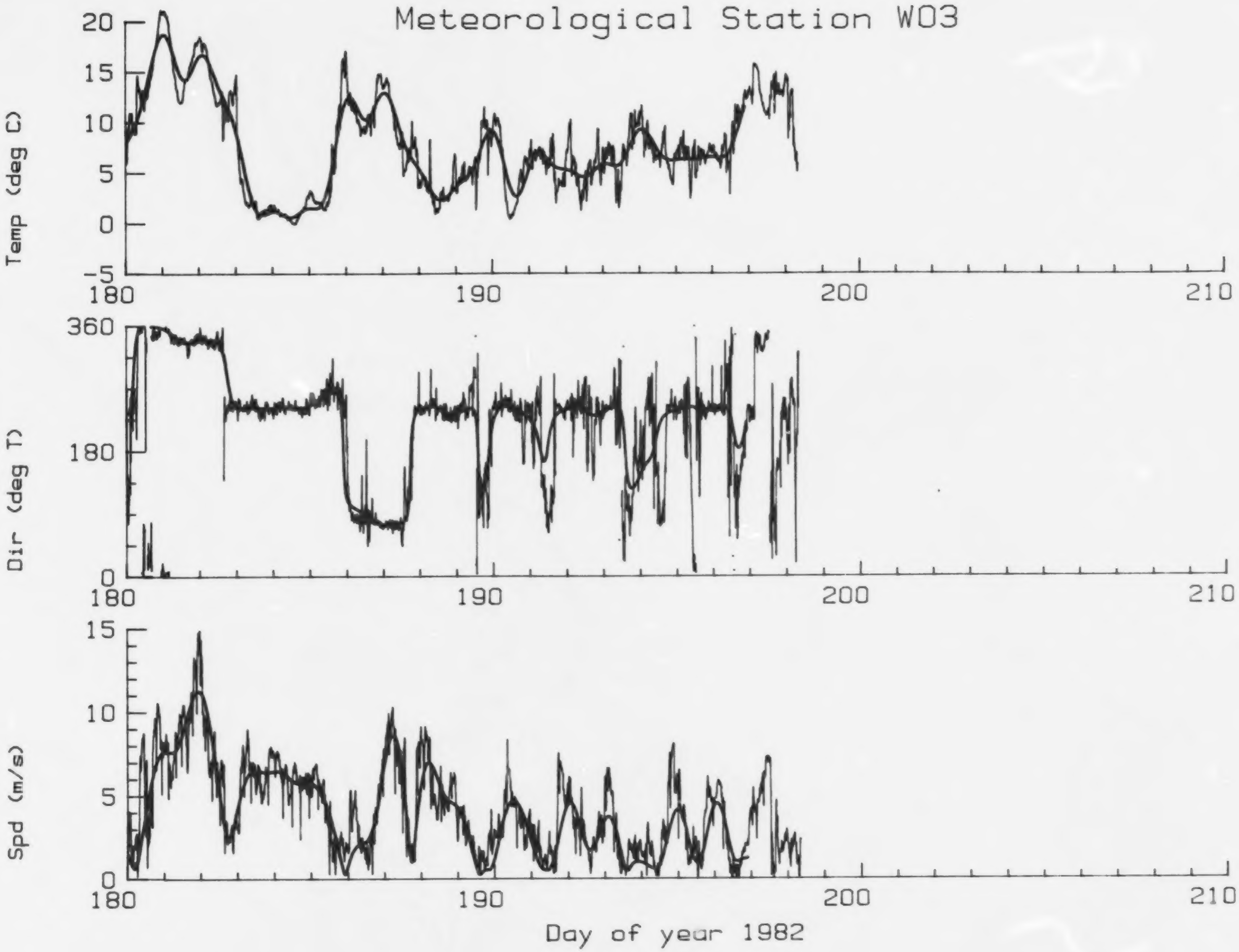
0
150
160
170
180
Day of year 1982


Meteorological Station W03
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15
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0
-5
Dir (deg T)
360
180
0
Spd (m/s)
15
10
5
0
180
190
200
210
Day of year 1982

Volume

2

Current and Sea-Level Measurements in the Northwest Passage
Volume 2, March 1983 - April 1984.

W.R. Buckingham, R.A. Lake and H. Melling

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C., V8L 4B2

1987

**Canadian Data Report of
Hydrography and Ocean Sciences
No. 51**

Canadä

Canadian Data Report Of Hydrography and Ocean Sciences

These reports provide a medium for the documentation and dissemination of data in a form directly useable by the scientific and engineering communities.

Generally, the reports will contain raw and/or analyzed data but will not contain interpretations of the data. Such compilations will commonly have been prepared in support of work related to the programs and interests of the Ocean Science and Surveys (OSS) sector of the Department of Fisheries and Oceans.

Data Reports are produced regionally but are numbered and indexed nationally. Requests for individual reports will be fulfilled by the issuing establishment listed on the front cover and title page. Out of stock reports will be supplied for a fee by commercial agents.

Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

Rapport statistique canadien sur l'hydrographie et les sciences océaniques

Ces rapports servent de véhicule pour la compilation et la diffusion des données sous une forme directement utilisable par les scientifiques et les techniciens.

En général, les rapports contiennent des données brutes ou analysées mais ne fournissent pas d'interprétations des données. Ces compilations sont préparées le plus souvent à l'appui de travaux reliés aux programmes et intérêts du service des Sciences et Levés océaniques (SLO) du ministère des Pêches et des Océans.

Les rapports statistiques sont produits à l'échelon régional mais sont numérotés et placés dans l'index à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page de titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Les établissements des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports depuis décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du Rapport n° 1 en janvier 1982.

Canadian Data Report of Hydrography and Ocean Sciences No. 51

1987

CURRENT AND SEA-LEVEL MEASUREMENTS IN THE NORTHWEST PASSAGE
VOLUME 2, MARCH 1983 - APRIL 1984.

by

W.R. Buckingham, R.A. Lake and H. Melling

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C., V8L 4B2

PREFACE

This report is the second of three data reports documenting current and sea-level measurements in the Northwest Passage of the Canadian Arctic Archipelago between March 1982 and April 1985. Each report deals with the activities undertaken during a year-long period. Analysis and interpretation of these data appear in two separate technical report.

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ABSTRACT

Buckingham, W.R., R.A. Lake, and H. Melling, 1987. Current and Sea-Level Measurements in the Northwest Passage. Vol. 2, March 1983 - April 1984. Can. Data Rep. Hydrogr. Ocean Sci. No. 51:84 pp.

A three-year program of current and sea-level measurements was undertaken between March 1982 and April 1985 in the Canadian Arctic Archipelago by the Institute of Ocean Sciences of the Department of Fisheries and Oceans. The measurements were in the form of time series, at fixed depths by self-recording instrument packages, of temperature, salinity, current speed, current direction and water pressure at the seafloor. The activities during each year of the study concentrated on a specific region of the Northwest Passage within the Archipelago. The emphasis in 1982 was on the western portion (M'Clure Strait, Prince of Wales Strait, and Viscount Melville Sound), in 1983 on the central portion (eastern Viscount Melville Sound and Barrow Strait), and in 1984 on the eastern portion (Barrow Strait and adjacent channels). This report discusses the aims of the project, the logistics of the 1983 field work, and summarizes the data acquired during that year in tabular and graphic form.

key words: Arctic Archipelago, Northwest Passage, temperature, salinity, current, tide.

RESUME

Buckingham, W.R., R.A. Lake, and H. Melling, 1987. Current and Sea-Level Measurements in the Northwest Passage, Vol. 2, March 1983 - April 1984. Can. Data Rep. Hydrogr. Ocean Sci. No. 51:84 pp.

De mars 1982 a avril 1985, l'Institut des Sciences de la Mer du MPO a réalisé un programme triennal de mesures du niveau de la mer et des courants dans l'archipel arctique canadien. Ces mesures ont été prises sous forme de séries chronologiques, à des profondeurs déterminées, par des groupes d'instruments automatisés, de la température, de la salinité, de la vitesse et direction de courant et de la pression de leau au fond de la mer. Les activités annuelles ont porté sur une région déterminée du passage du Nord-Ouest de l'archipel. En 1982, l'accent a été mis sur la partie ouest (détroit de M'Clure, détroit de Prince-de-Galles, et détroit du Vicomte-Melville), sur la partie centrale en 1983 (parti est du détroit du Vicomte-Melville et détroit de Barrow), et en 1984, sur la partie est (détroit de Barrow et chenaux adjacents). Le présent rapport porte sur les buts du projet, le soutien logistique du travail sur le terrain en 1983 et résume les données recueillies cette année-là, qui sont présentées sous forme de tableaux et de graphiques.

Mots-clés: archipel arctique, passage du Nord-Ouest, température, salinité, courant, marée.

ACKNOWLEDGEMENTS

The authors wish to thank various members of the Institute of Ocean Sciences whose diligent efforts helped to make this project a success. In particular we thank electronics technician P. Johnston, support technicians S. Moorhouse and G. Moonie, and J.W. Green from the computing section. Logistic support, and accommodation at Resolute Bay was provided by the Polar Continental Shelf Project of the Department of Energy, Mines and Resources. Meals, radio and accommodations were also made available at Rae Point by Panarctic Oils, Ltd. We sincerely thank both organizations, and the particular individuals involved, for their cooperation and assistance. The loan of the tethered submersible DART, with its skilled operator Steve Taylor, by the Defence Research Establishment - Pacific, is greatly appreciated.

The funding for this project was provided by the Marine Transportation Research and Development Programme.

1. INTRODUCTION

A three-year physical-oceanographic study was undertaken between 1982 and 1985 in the Canadian Arctic Archipelago, centering on the complex of waterways known as the Northwest Passage. The study was carried out by the Department of Fisheries and Oceans at the Institute of Ocean Sciences (IOS). It extended from Amundsen Gulf in the west, through Prince of Wales Strait, M'Clure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound to Baffin Bay in the east (see Figure 1). The study also included the various passageways and basins bordering the Northwest Passage. The overall objective included the following goals:

1) the identification of the magnitude and direction of tidal and non-tidal currents,
2) the description of tidal propagation,
3) the identification of sources and destinations of various water-masses,
4) the identification of the relative importance of physical forces which determine currents and water-mass distribution (e.g. tidal forces, baroclinic forces related to horizontally inhomogeneous distribution of water density and non-tidal barotropic forces related to oceanic and atmospheric circulation),
5) the identification of temporal and spatial variability in current and water-mass distribution. Periods of particular importance are tidal (semi-diurnal and diurnal), seasonal, and interannual. Also of potential importance are singular or non-periodic events such as storm surges,
6) the estimation, to an order of magnitude, of the volume of water transport into and out of the study area and the partition of that transport.

The activities during each year of the study concentrated on a specific region of the Northwest Passage. The emphasis in 1983 was on eastern Viscount Melville Sound and adjacent passages. The field operations were undertaken during the early spring months, at which time the solid ice-cover made a stable platform from which to work.

This report describes the acquisition of water-current and sea-level information in 1983/84 as time series of current, temperature, salinity and sea-floor pressure and presents the data in final processed form. The main study area comprised the eastern end of Viscount Melville Sound, the western part of Barrow Strait, Austin Channel, Byam Martin Channel and northern M'Clintock Channel. The relevant mooring locations are indicated by the square symbols in Figure 2 and the tide gauges are indicated by circular symbols. Tide gauges operated by other agencies are shown as diamond symbols. Data reports covering the activities during 1982 and 1984 may be found in Volumes 1 and 3 of this report series.

Relevant ocean measurements were acquired concurrently by the Canadian Hydrographic Service in Prince Regent Inlet (CHS-Central: seafloor pressures) and by the Bayfield Laboratory for Marine Science and Surveys in Barrow Strait (DFO-Central: seafloor pressures and current). The Canadian Hydrographic Service maintain, tide stations at Cape Parry and Resolute Bay, and in 1983/84 maintained stations at Mould Bay, Isachsen and Auldhild Bay. Most of these moorings are indicated by star symbols in Figure 2.

The study area has not previously been extensively investigated due to its remoteness and to the difficulty of ship operations. The sea surface is completely frozen during most of the year, and is often ice-choked during the

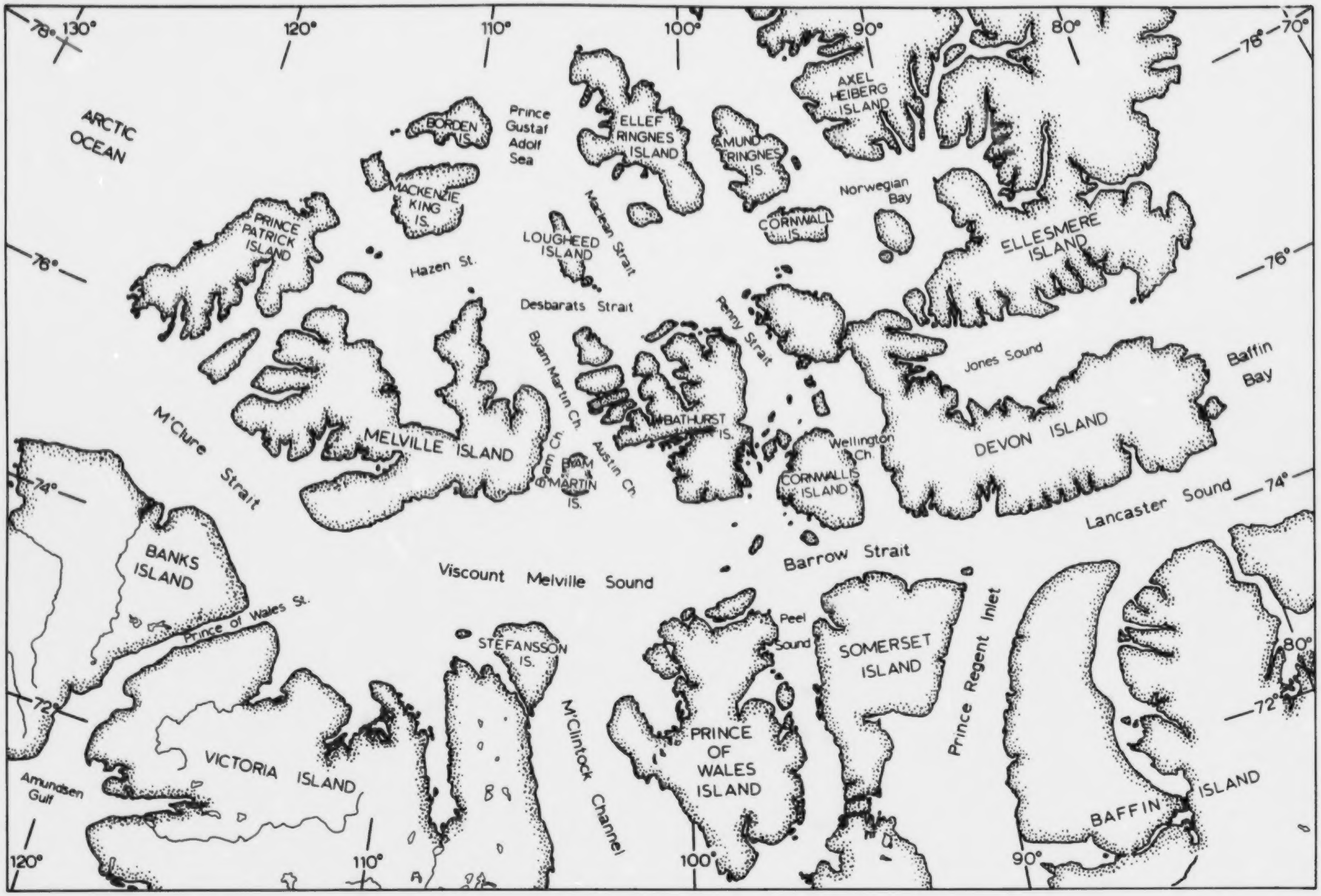

Figure 1. A map of the Canadian Arctic Archipelago. The Northwest Passage shipping route will likely be through Lancaster Sound, Barrow Strait, Viscount Melville Sound, and Prince of Wales Strait.

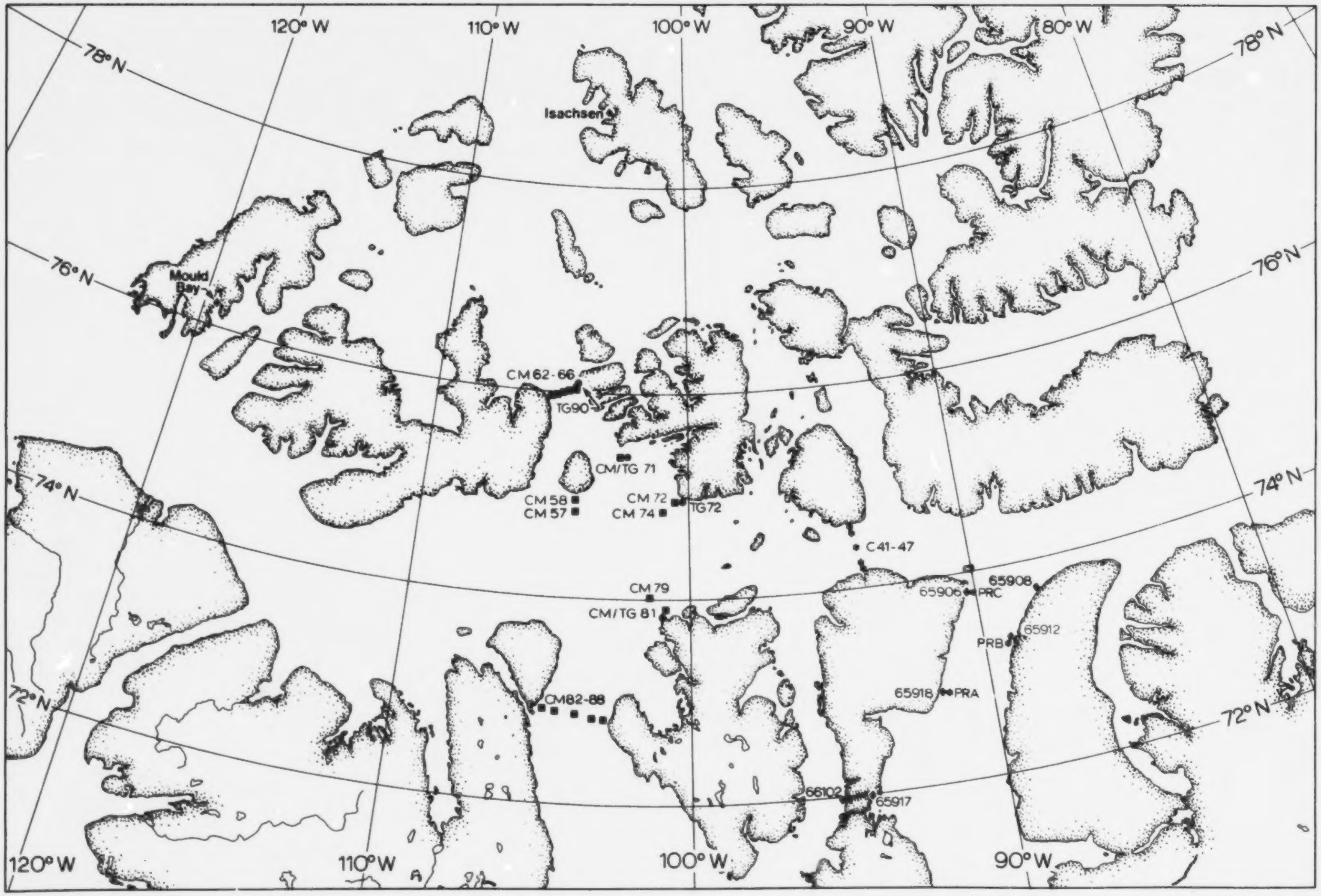

Figure 2. Location of recording instrumentation moorings throughout the Arctic Archipelago in 1983 (squares - current meters; dots - tide gauges; stars and diamonds - current meters and tide gauges from concurrent studies by other agencies.)

short navigation period. Previous oceanographic research in the Arctic Archipelago has been tabulated by Fissel, Knight and Birch (1984). The earliest significant collection of oceanographic data was accomplished from ships in summer during the 1950's and 1960's. These data were sufficient to delineate the regional water-mass characteristics. In 1976 and 1977 direct current measurements were made in Byam and Austic Channels and Crozier and Pullen Straits by the Institute of Ocean Sciences. In 1977 and 1978 investigators from the Physical Oceanographic Group of the Canada Centre for Inland Waters completed a number of current meter transects across Viscount Melville Sound, Prince of Wales Strait, and adjacent channels (Peck, 1978 and Prinsenberg, 1978). Current data across the western end of Viscount Melville Sound were gathered in 1979 as part of the Polargas Project (1979). A number of tidal height measurements were made during 1979 and 1980 as part of the Bridport Inlet studies by IOS. The Canadian Hydrographic Service also made extensive tidal height measurements in 1977, and an additional tidal height record was obtained as a part of the Polargas program in 1979.

The present study involved measurements by CTD probe, recording current meters, tide gauges, and meteorological stations. This report deals with the recording instrument measurements. Section 2 describes the physical setting and bathymetry of the study area and the mooring locations during 1983/1984. Section 3 recounts the logistics, equipment used, and the timing of the measurements, while Section 4 deals with the data processing procedures. The data are presented as time-series plots in the Appendix.

2. PHYSICAL SETTING AND STATION LOCATIONS

2.1 Arctic Archipelago

The Canadian Arctic Archipelago consists of a large group of islands lying on the extensive polar continental shelf of North America (Figure 1). The Archipelago extends roughly 1500 kilometers between the 68° and 82° North latitude and about 2700 kilometers between 60° and 130° West longitude (at 70° North). These islands are bounded to the north and west by the Arctic Ocean and the Beaufort Sea respectively, to the south by the mainland of the North American continent and to the east and southeast by Nares Strait, Baffin Bay, Davis Strait, and Labrador Sea. For convenience, the Archipelago is often divided into three sections from north to south as follows: the Sverdrup Basin lying within the Queen Elizabeth islands (i.e., all islands north of Parry Channel); Parry Channel, consisting of M'Clure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound; and the "Southern Channels" comprising Amundsen Gulf, M'Clintock Channel, the Gulf of Boothia, and other, lesser waterways.

2.2 General Bathymetry

The channels and basins throughout the Archipelago are in general substantially shallower than the major adjoining oceanic basins. The continental shelf effectively limits free passage of water to maximum depths of about 450 meters into Sverdrup Basin, to about 380 metres into M'Clure Strait, and to about 360 meters into Amundsen Gulf. To the east, Baffin Bay has depths up to 2300 meters, but the sill in Davis Strait (to the south of Baffin Bay) limits deep water exchange with the North Atlantic to depths of less than 700 meters. Another shallow entrance (50 meters) to the Archipelago from the North Atlantic exists through Hudson Strait, Foxe Basin, and Fury and Hecla

Strait in the south. The deepest continuous passage through the Archipelago exists through Parry Channel and has a limiting sill of 125 meters in Barrow Strait. The passageways connecting Sverdrup Basin to the southern channels (M'Clure Strait, Viscount Melville Sound, Barrow Strait, etc.) are in general constricted by shallow sills on the order of 100 meters in depth. South of Parry Channel depths are characteristically shallow (mostly less than 200 meters) with the exception of some deeper areas of greater than 400 meters extending into Prince Regent Inlet from Lancaster Sound.

2.3 Mooring Locations and Local Bathymetry

The Northwest Passage field study in 1983 was concentrated on the eastern end of Viscount Melville Sound. The study area was bounded on the north by Melville Island, Byam Martin Channel and Bathurst Island, on the east by the 100° West meridian (approximately), on the south by Stefansson Island, M'Clintock Channel and Prince of Wales Island, and on the west by the 106°W meridian. Due to the large size of the area studied (about 50,000 square kilometres) only near-surface currents were measured systematically over the area, and even for the surface-measurement arrays, mooring spacing was substantially greater than internal deformational and topographic scales of variability. In anticipation of shoreline "hugging" baroclinic flows, meters were more closely spaced near shores. Two complete transects were instrumented across Byam Martin Channel and M'Clintock Channel and partial transects were instrumented at channel junctions near Capes Gillman, Cockburn and Berkeley (see Figure 2). Recording pressure gauges were deployed at Capes Aldrich, Cockburn and Berkeley, and at the base of the mooring in central Austin Channel. Vertical variation of current was measured at one location in central Austin Channel.

Concurrent measurements of current and seafloor pressure were acquired by the Canadian Hydrographic Service in Prince Regent Inlet and by the Bayfield Laboratory for Marine Science and Surveys in Barrow Strait. Farther afield the Canadian Hydrographic Service made sea-floor pressure measurements at Mould Bay, Isaachsen, Auldhild Bay and Pond Inlet, in addition to continuing longterm measurements at Cape Parry, Alert and Resolute Bay. These locations are plotted, where possible, in Figure 2.

Instrument location, depth, type, serial number, recovery success and observational period are tabulated for this program, and for concurrent studies, in Table 1.

The bathymetry of the channels in the vicinity of the instrument moorings is shown in Figure 3. Figure 3 shows the bathymetry of the western boundary to be smoothly sloping from the north and the south, with the deepest point (about 500 m) occurring at about one third of the width from the south shore. The square and triangular symbols of this figure denote 1982 and 1983 moorings respectively. From this point to the eastern boundary the seafloor shoals and flattens, so that along 100°W, all depths are less than about 150 m. To the south, a sill of about 270 m depth walls a deeper basin in M'Clintock Channel, while to the north, complex bathymetry between 100 and 250 m depth extends to deeper waters northwest of Byam Martin Channel. Two significant obstructions in this area are Byam Martin Island, and Keene Bank, which shoals to depths near 7 m at 75.2°N 102°W.

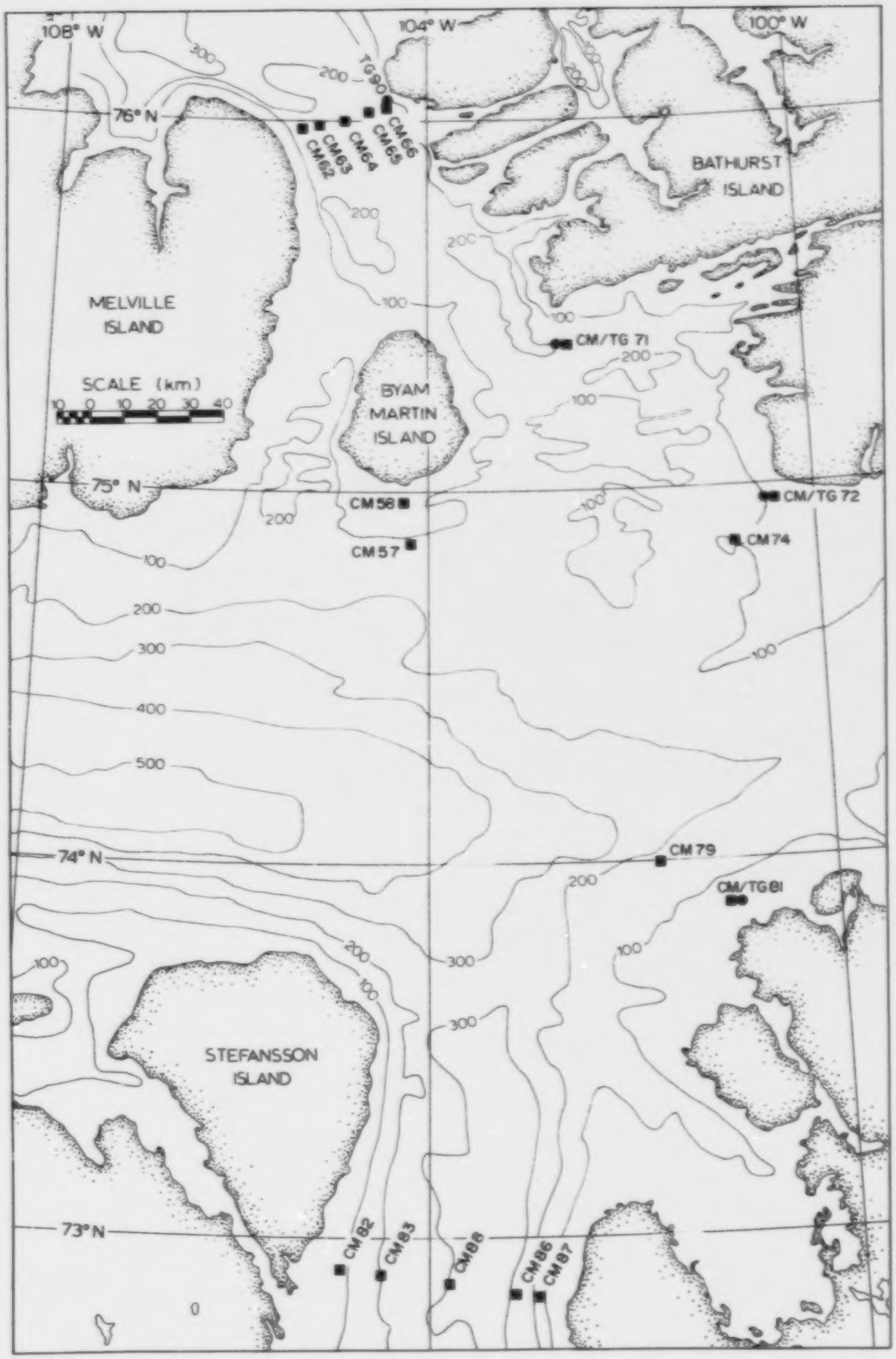

Figure 3. Bathymetry of the eastern part of Viscount Melville Sound, M'Clintock Channel, and Byam Martin Channel (squares - current meters; dots - tide gauges.)

In the following table, CCIW = Canada Centre for Inland Waters, T and C = Tides and Currents Section of Department of Fisheries and Oceans, CHS = Canadian Hydrographic Service.

Table 1. Summary of Recording Instrument Records

Region	Site	S/N	Latitude	Longitude	Type	3 mos.	12 mos.	Depth (m)	Data Recovery/ Remarks
Byam Martin Island	CM57	1939	74°51.6'	104°12.8'	RCM	✓		18	✓
	CM58	1936	74°59.1'	104°13.4'	RCM	✓		18	✓
Byam Martin	CM62	3223	75°55.6'	105°22.6'	RCM	✓		18	✓
"	CM63	3278	75°58.1'	105°10.6'	RCM	✓		18	✓
"	CM64	3228	76°00.5'	104°54.6'	RCM	✓		18	x instr. malf'n.
"	CM65	3387	76°02.9'	104°38.8'	RCM	✓		18	✓
"	CM66	3388	76°04.6'	104°27.9'	RCM	✓		18	✓
Austin Channel	CM71	3395	75°23.3'	102°38.6'	RCM	✓		18	✓
"	CM71	2466			RCM		✓	73	✓
"	CM71	2470			RCM		✓	123	✓ 1 change in ref. direction
Cape Cockburn	CM72	2467	74°57.1'	100°26.9'	RCM	✓		18	✓
"	CM74	1932	74°51.0'	100°49.7'	RCM	✓		18	✓
Cape Berkeley	CM79	1931	74°00.2'	101°39.8'	RCM	✓		18	✓
"	CM81	5361	73°52.9'	100°59.7'	RCM	✓		18	✓
M'Clintock Channel	CM82	1930	72°56.3'	104°52.0'	RCM	✓		18	✓
	CM83	5456	72°54.8'	104°29.0'	RCM	✓		18	✓
"	CM86	5474	72°51.9'	103°08.6'	RCM	✓		18	✓
"	CM87	0972	72°50.5'	102°54.1'	RCM	✓		18	✓
"	CM88	1929	72°52.7'	103°46.2'	RCM	✓		18	x lost

Table 1. Summary of Recording Instrument Records (continued)

Region	Site	S/N	Latitude	Longitude	Type	3 mos.	12 mos.	Depth (m)	Data Recovery/ Remarks
Barrow Strait	C41		74°36.2'	94°02.8'	RCM	✓		10	✓ CCIW
"	C42A		74°34.0'	94°01.1'	RCM	✓		10,40, 60,80,120	✓ CCIW
"	C44		74°24.1'	93°54.7'	RCM	✓		10	✓ CCIW
"	C46A		74°13.3'	93°38.3'	RCM	✓		10,40, 60,80,120	✓ CCIW
"	C47		74°11.7'	93°35.3'	RCM	✓		10	✓ CCIW
"	C42B		74°34.0'	94°01.1'	RCM		✓	40,80,110	x CCIW, lost
"	C46B		74°13.3'	93°38.3'	RCM		✓	40,80,110	x CCIW, lost
Austin Channel	CM71	0301	75°23.3'	102°38.6'	TG4		✓	173	x P_{max} = 270 dbar; instr. malf'n.
Cape Cockburn	TG72	0366	74°57.1'	100°26.9'	TG5A	✓		76	✓ P_{max} = 270 dbar
Cape Berkeley	TG81	0367	73°52.9'	100°59.7'	TG5A	✓			x lost
Byam Martin Channel	TG90	0080	76°05.5'	104°25.5'	WLR5A	✓		110	✓ P_{max} = 270 dbar
Barrow Strait	C42A		74°34.0'	94°01.1'	TG	✓		129	✓ CCIW
"	C44		74°24.1'	93°54.7'	TG	✓		158	✓ CCIW
"	C46		74°13.3'	93°38.3'	TG	✓		162	✓ CCIW
Auldhild Bay					TG		✓		✓ CHS
Isachsen					TG		✓		✓ CHS

3. DATA COLLECTION

3.1 Instrumentation

In total, 19 recording current meters and 4 recording pressure gauges were deployed in March and April 1983 within the study area delineated in Section 2.3. Of the current meters, 17 were suspended from the ice for a deployment of between one and three months at shallow depth (~20 m). These meters were Aanderaa Instruments, Ltd. RCM4's, modified at the Institute of Ocean Sciences to the 'vane-follower' configuration described below. The remaining 2 current meters were also Aanderaa RCM4's in the 'vane-follower' configuration, and were used on the 12-month deployment in Austin Channel, where stable ice for suspension could not be expected throughout the deployment. A Mesotech acoustic release (Model 501AR) was used to secure the subsurface mooring in Austin Channel. Recording pressure gauges were manufactured by Aanderaa Instruments, Ltd. (models, as noted in Table 1: TG4A, WLR5A). All gauges use the Paroscientific, Inc. Digiquartz pressure transducer, with full-scale pressure ranges as indicated in Table 1.

Special modification to the RCM4's was as follows: Two or more of the resistors in each of the bridge circuits for temperature and conductivity ratio were exchanged for values yielding 10-bit resolutions of about 0.005°C and 0.00016 respectively, and ranges centred on those of interest. For temperature this range was typically (-2.5°C, +2.5°) and for salinity approximately (29, 35). Resolution in salinity was about 0.006. Aanderaa current meters were deployed in lengthened pressure cases which permit the installation of two batteries, desireable for long records at low water temperature. In the 'vane follower' configuration, a small (8.7 cm high by 5.8 cm wide) vane was suspended beneath the pressure case in mounts held by 3 stainless steel rods about 6 mm in diameter. The vane was neutrally buoyant in seawater. The field from two magnets mounted above the vane and free to turn with it was adequate to orientate the compass within the case. In this way current direction relative to the case was measured, while geographic orientation of the case was established at deployment and maintained until recovery.

Three methods were used for positioning moorings. Pressure gauge moorings nearshore were sited by sextant relative to natural landmarks, or to markers set up for the purpose. Moorings more than a few hundred meters from shore were positioned using a GNS-500A VLF/Omega navigation system installed on the deploying aircraft and initialized at nearby geodetic survey points. This allowed positioning to within a 500 m radius. The bottom-founded mooring in Austin Channel was positioned to an accuracy of a few meters using microwave transponders (a Del Norte system) deployed at known locations for this purpose. Sites where moorings were to be recovered before the break-up of fast ice in summer were marked by 4-foot square by 1-foot high aluminum marker boxes painted red, and by radio beacons operating at 130 MHz (Novatech Designs Ltd., Model RF200). Sites where moorings were to be recovered one year later were marked by underwater acoustic beacons operating at 37 kHz (Johnson Laboratories, Inc., Model JL1).

3.2 Mooring Design, Deployment and Recovery

'Vane-follower' current meters were suspended from the sea ice on 1-inch hydraulic hose (see Figure 4). The hose was chosen because of its high torsional rigidity despite reasonable bending flexibility. Resistance to twisting

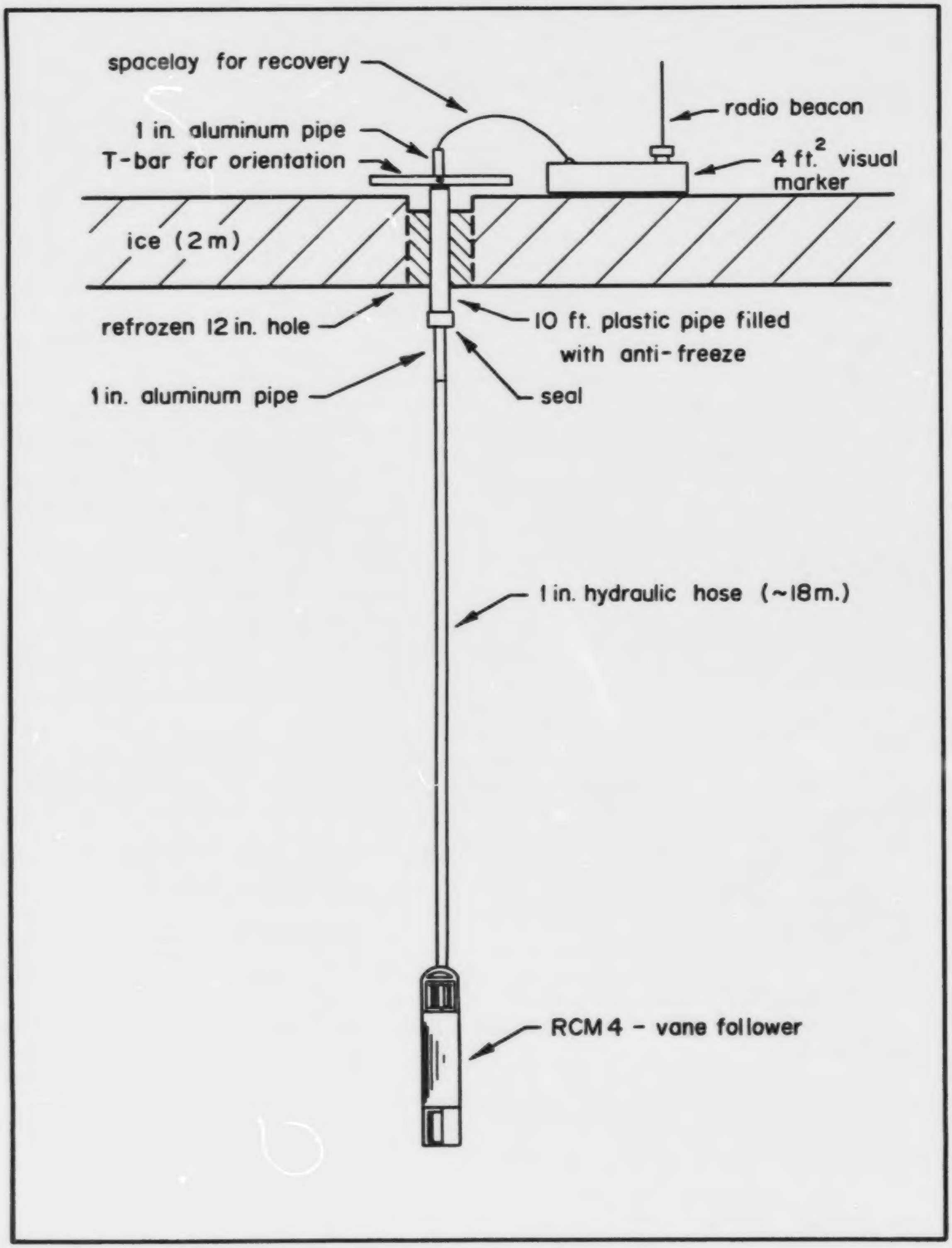

Figure 4. Vane-follower current meters suspended from the sea-ice on hydraulic hose.

was essential for maintaining a direction reference for current measurement. Meter depth was 18.5 m below the upper ice surface for all near-surface instruments. The hose was terminated and bolted to a 1-inch aluminum pipe just below the ice. This 12-foot pipe, and a vinyl-coated cable within it passed through the ice inside a 10-foot pipe of polyvinyl chloride plastic (PVC). A rubber seal between the metal and PVC pipes at the lower end of the latter permitted the space between the pipes to be filled with a 50/50 ethylene glycol/water solution. A crossbar at the top of the metal pipe held the weight of the mooring and allowed mooring orientation (and that of the current meter) to be established. The assembly was deployed through an 8-inch-diameter hole augered in the ice and allowed to freeze in. The plastic-coated cable was crimped to the square site marker as a security measure. At the time of recovery, an 8-inch hole was augered beside the mooring and the crossbar on the mooring removed. The metal pipe was then lowered on the cable until well clear of the ice. At this point, the cable was hooked by a pole manipulated through the adjacent hole and the assembly pulled through this hole to the surface. The PVC pipe (still frozen in the ice) was abandoned. Simulation of the mooring response to flow using the model of Bell (1979) indicated that the vertical displacement of the current meter was only 0.2 m with a 50 cm/s current.

Current meters in "vane follower" configuration were used at site CM71 in Austin Channel on the bottom-founded mooring (see Figure 5). Flotation was provided by a single 28" diameter steel float (Ocean Research Inc., Model SS28). The principal mooring "line" was assembled on site from aluminum tubing (10-foot lengths) of 1" diameter. Current meters were mounted in load-bearing frames made from two 1/2"-diameter stainless steel rods spread to a separation of 8" to allow inclusion of the RCM4. Frames were about 4 feet in length, and were bolted in line with the tubing. The anchor consisted of steel chain lengths contained in a 45-gallon oil drum with a harness of steel flat stock to reinforce it. Steel feet penetrated the sediment to minimize anchor movement. The mooring was attached to the anchor via a universal joint from an automobile which permitted bending in any plane, but no twisting. The overall intent of the design was to achieve a high degree of torsional rigidity while allowing bending. Magnetic compasses could not be used at this site due to the weak horizontal geomagnetic field. Orientation of the mooring was determined after deployment. A single acoustic transponding release was used on the mooring. Current meters were positioned at depths of 73 m and 123 m. Pressure records from the uppermost RCM4 indicated negligible (<1 m) fluctuations in meter depth in response to current drag on the mooring. The deployment winch, quadripod, ice-hole melter and other mooring gear were designed and built at the Institute of Ocean Sciences to meet the requirements of the task, and yet be aircraft transportable.

Recording pressure gauges were moored in two ways. Those gauges required for tidal description, and short-term (1-3 month) deployment were strapped above a steel or lead ballast weight and lowered to upright position on the seafloor (see Figure 6). Sufficient slack was left in the polypropylene rope to accommodate sea-level variations, and the rope was secured to the marker box on the ice. For recovery, a hole was augered in the ice adjacent to the in-frozen rope, the rope hooked and the instrument raised from the seafloor. For the gauge moored in Austin Channel over 12 months, a cradle was welded to the anchor bucket of the RCM mooring. A slack line connected the mooring to the gauge in order that the mooring, when released, would also raise the gauge to the surface.

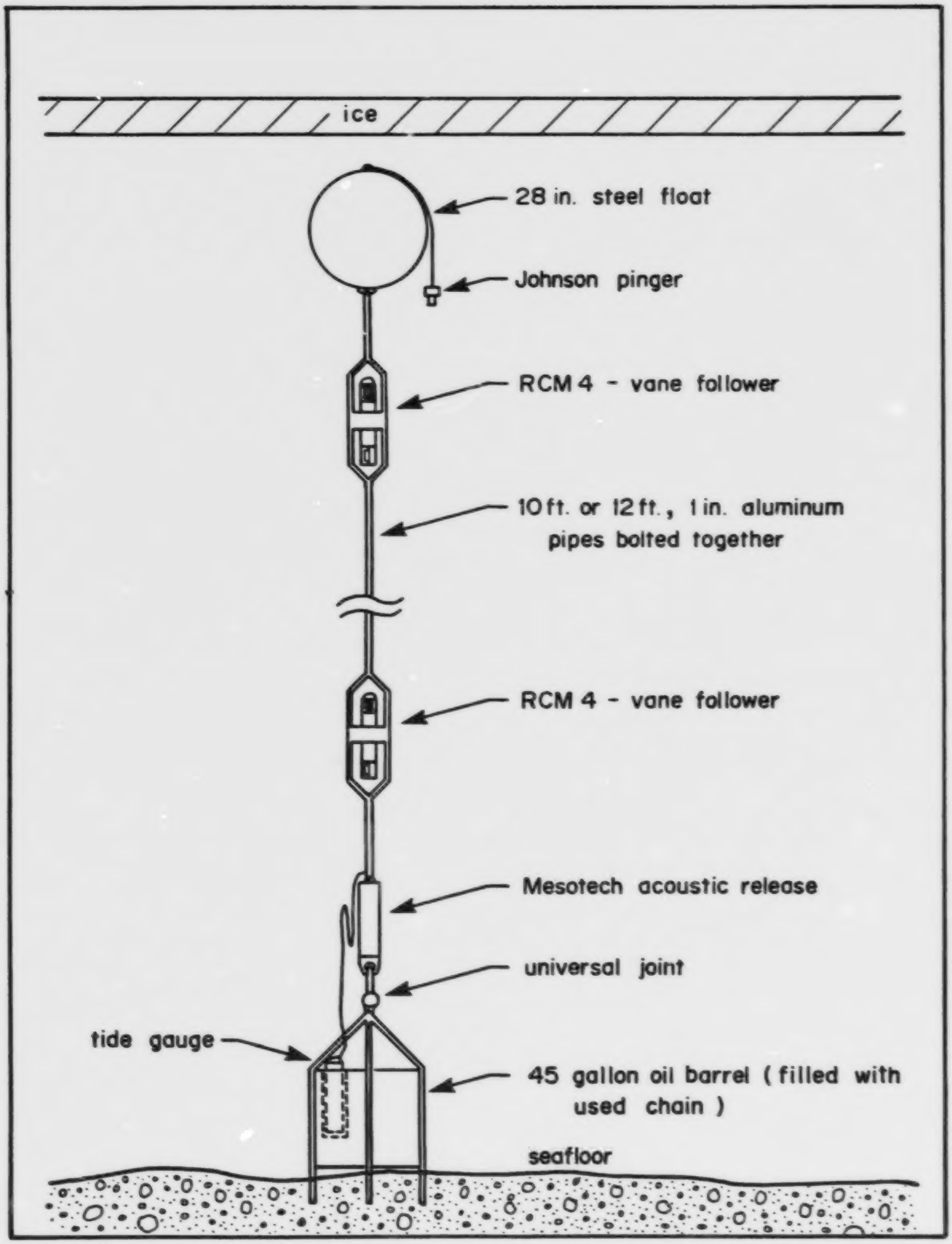
ice
28 in. steel float
Johnson pinger
RCM 4 - vane follower
10 ft. or 12 ft., 1 in. aluminum pipes bolted together
RCM 4 - vane follower
Mesotech acoustic release
universal joint
tide gauge
45 gallon oil barrel (filled with used chain)
seafloor

Figure 5. Bottom-founded mooring with vane-follower current meters.

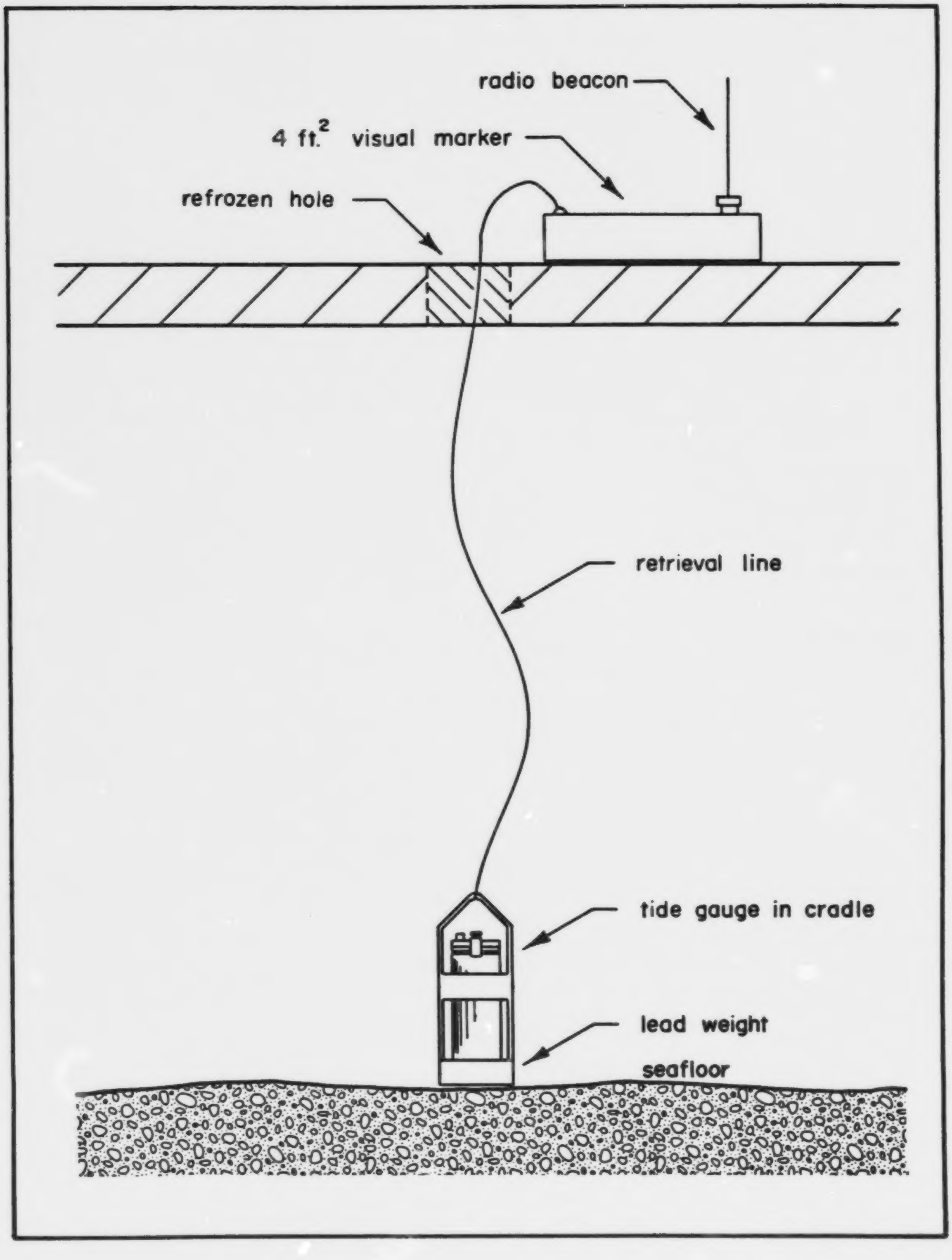

Figure 6. Mooring for short-term tide gauge deployment.

Mooring operations were conducted during the first week of April 1983. Activity was supported from the Panarctic Oils Ltd. supply base at Rae Point. Most operations were carried out from a chartered Bell 206L-1 helicopter, while caches of fuel and equipment were established in the working areas by deHavilland DHC-6 Twin Otter on ski/wheel gear.

Recovery of ice-secured instruments was accomplished between 22-23 May and 10-11 June 1983, using a Bell 205 helicopter. Two instruments were not recovered. An RCM at site CM88 in M'Clintock Channel was abandoned on account of poor visibility and a non-functional VHF beacon, while the tide-gauge installation at Cape Berkeley had been damaged by bears and the tether line could not be located.

Retrieval of bottom-mounted instruments was attempted in late April 1984 using a Twin Otter for transport. The mooring at CM71 was easily located, but the release failed to function because the drive motor operating the hook remained stalled. A tethered submersible, the Dart (International Submarine Engineering, Ltd., Vancouver) was borrowed from a Department of National Defense (DREP) camp about 200 miles distant and flown to the site. The operator was able to locate the anchor clump of the mooring at 175 m depth using sonar and a video camera on the submersible, and to attach a line to the float at 70 m depth. The mooring, including its anchor, was then winched to the surface, and the instruments recovered in the normal fashion.

The timing of successful operational periods of the recording instrumentation is shown in the bar chart of Figure 7.

3.3 Calibration

Current meters were deployed with sensors for current speed, direction, water temperature and conductivity. The speed sensors were not calibrated for this deployment, since experience has shown the calibration to be stable provided that rotor bearings are well maintained. Rotor thresholds were verified to be within tolerance by testing for rotation in response to a minimum torque specified by Aanderaa Instruments. It should be noted that in the 'vane follower' configuration, flow may approach the meter from any direction. (In the standard configuration flow is always at right angles to the rotor support yoke). It has recently been established (Pite, 1986) that in some directions, the support interferes significantly with the rotor response to flow. As the result the rotor sensitivity is azithmuthally non-uniform (see Figure 8). Further anisotropy is contributed by the presence of the load-bearing rods of the RCM mounting frame. Since no corrections for these effects were made in processing these data, they contribute an imprecision in speed of about ±7%.

In the 'vane follower' configuration uncertainties in direction measurement arise from the following sources: nonlinearity in vane response to current; non-linearity in encoded compass reading to vane position; inaccuracy in carrying the reference direction up the 20 m of hydraulic hose and aluminum pipe from the instrument case to the crossbar at the surface; and inaccuracy in referencing the crossbar orientation to geographic north. The nonlinearity in vane response to current arises from the interaction of the flow with the 3 rods supporting the vane bearing and the 2 thicker rods supporting the current meters (Pite, personal communication). Vane orientations aligned with a downstream support rod are avoided. Since no correction has been made for this effect in processing these data, an imprecision of about ±7° in direction is thereby contributed. The non-linearity in compass response to vane position arises from the interference of the geomagnetic field and any

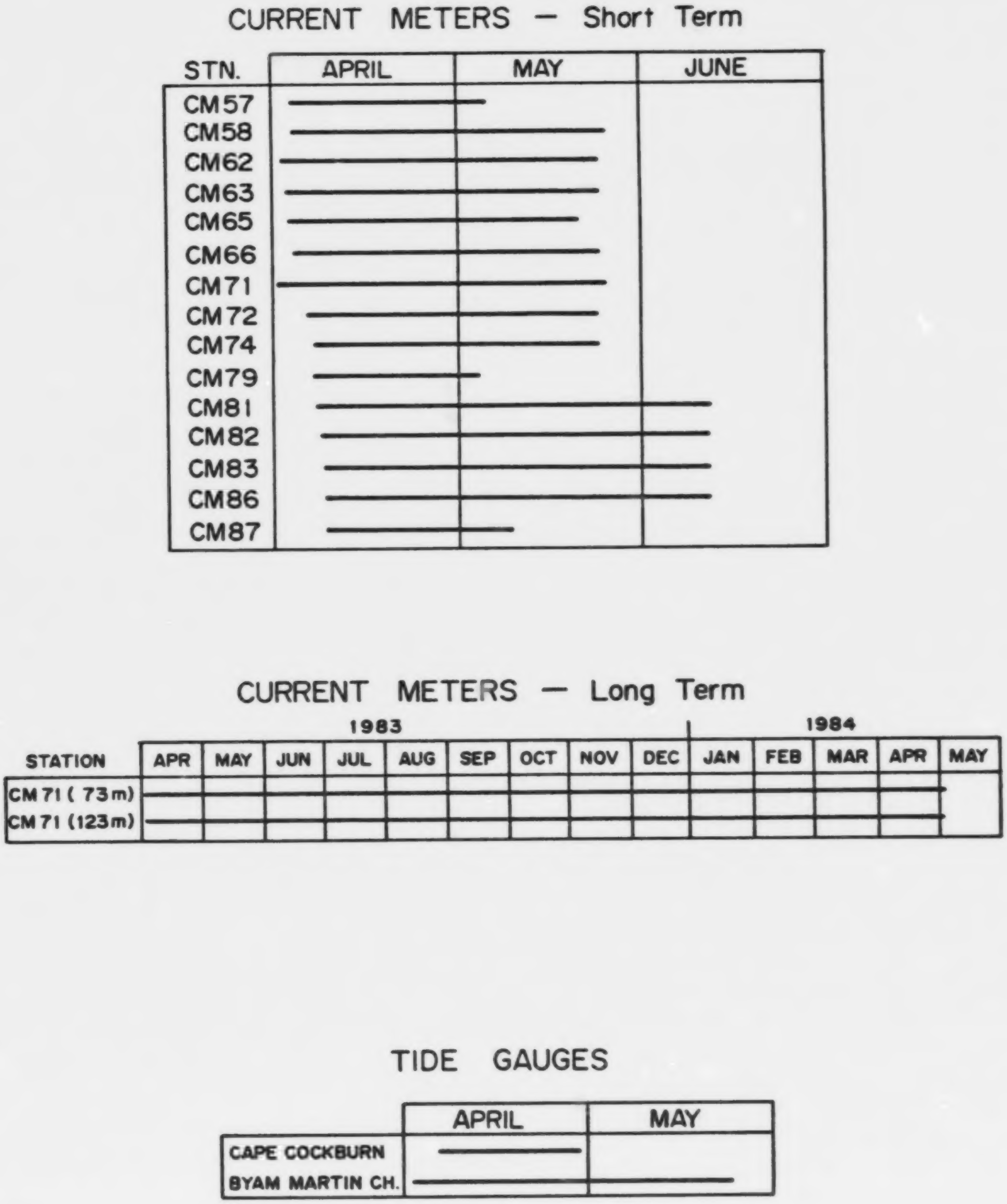

Figure 7. Bar chart of operational periods for recordings instrumentation.

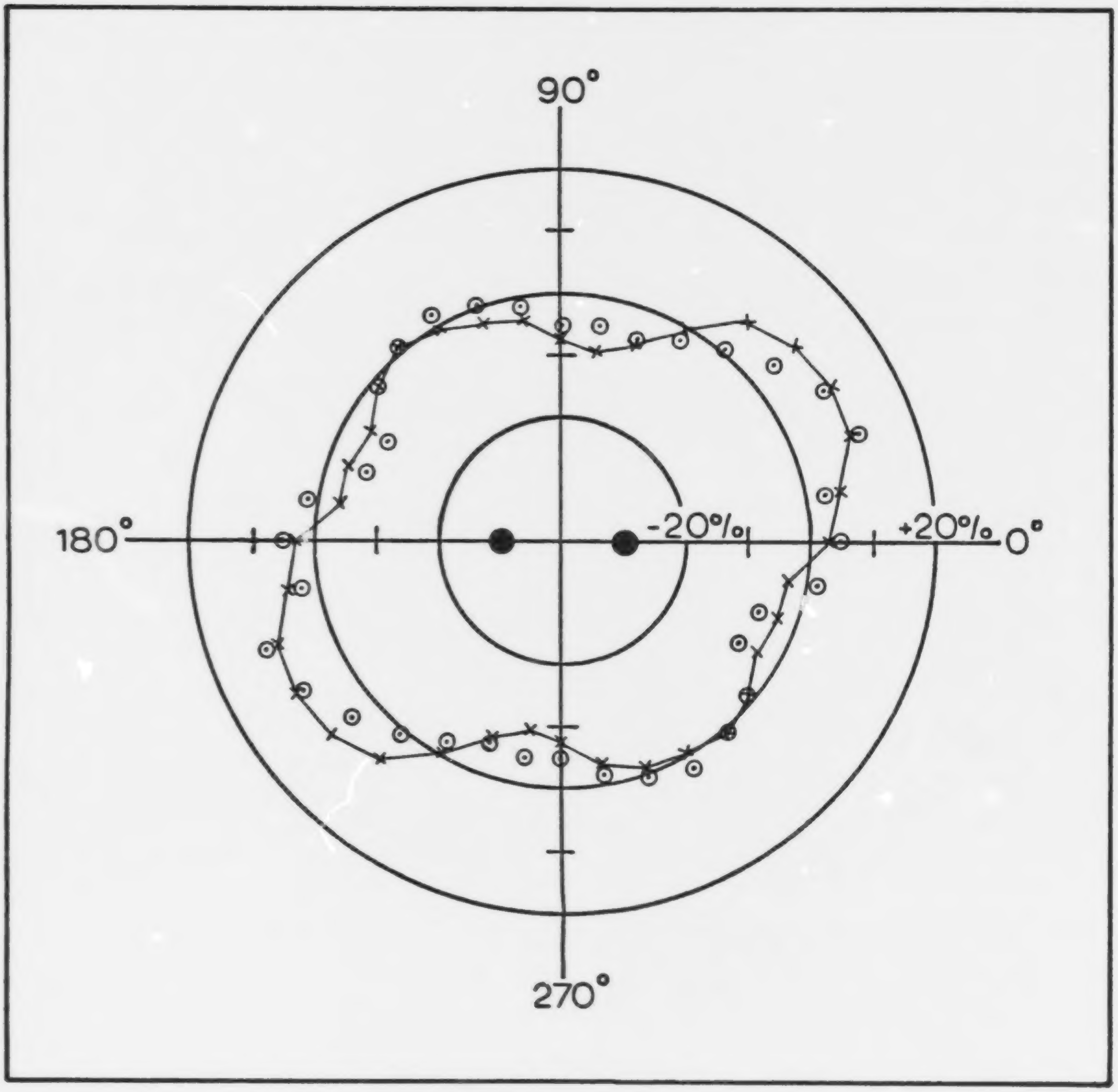

Figure 8. Plot of current meter rotor sensitivity versus azimuth for a two rod support configuration.

remnant magnetism in the instrument case with the magnetic coupling between the vane magnets and the compass, from any departure in concentricity between the vane and the compass pivots and from nonlinearities in the compass potentiometer. The combined effect of these factors was measured near the mooring sites before deployment (at Rae Point) and appropriate corrections (as large as 11.5° peak-to-peak) were made during processing. The uncertainty in these corrections contributes a further imprecision of ±3° to direction measurement. Difficulties in carrying the direction reference from the current meter to the crossbar produce an inaccuracy of about ±5°, while those in referencing the crossbar orientation to geographic north produce a further inaccuracy of about ±3°. (Crossbar orientation was determined by measuring the angle between the crossbar and the sun with an astrocompass, and by determining the solar azimuth from sun tables knowing the measurement time and position). For the long pipe moorings, accuracy and precision are less good. The mooring in 170 m of water contained about 33 lengths of tubing. It is not unreasonable to assume that the bolt holes at opposite ends of each length of 1-inch tubing were misaligned, with a root-mean-square misalignment of 5°. If these misalignments were random, then the uncertainty over 33 lengths grows to about ±30°. In addition the mooring may be subject to elastic torsional deformation. An investigation of this possibility over a 30 m length of mooring at mid-latitude, where direction could be measured independently by magnetic compass, gave a root-mean-square discrepancy between the two methods of ±5° for currents peaking at 50 cm/s. If this discrepancy scales linearly with the length of the mooring then an imprecision of ±15° from this source may be estimated for the pipe mooring in Austin Channel at similar currents.

Temperature sensors on the current meters were calibrated in a large insulated sea water bath whose temperature was controlled to within one or two millidegrees Celsius. Sensor output was determined at 6 or 7 temperatures spanning the range, and a cubic polynomial equation for temperature fitted. Bath checks before and after deployment, and *in situ* comparisons with output from a profiling CTD have verified that accuracy and precision equal the resolution of 0.005°C.

Conductivity sensors on the current meters were calibrated in the same bath at two or three different conductivities and a linear equation for conductivity ratio was fitted. Bath salinity was determined by analysis of samples on a Guildline AutoSal salinometer. Experience has shown that bath calibrations are not reliable predictors of *in situ* performance, for reasons which are not well understood. *In situ* comparisons with output from a profiling CTD at the moorings in Prince of Wales Strait in 1982 showed RCM salinity offsets ranging as far as +0.13 from laboratory calibrations, with an average departure of +0.06. *In situ* comparisons at the other moorings in 1982 were not as well controlled, but yielded similar values. Calibration equations for measurements in 1983 were not, however, adjusted in accordance with the *in situ* calibrations. Accuracy and precision in salinity measurement are thus estimated to be ±0.1 and ±0.03, respectively.

Digiquartz pressure gauges were calibrated by Aanderaa Instruments Ltd., at a single fixed temperature (generally 0°C) by applying known pressures with dead-weight tester (Ruska Model 2465-751-00). Output values at 10-20 different pressures were fitted to a polynomial equation with a precision of approximately 0.01% fs. Reproducibility of deadweight pressures was about 0.05 dbar. Their absolute accuracy depends on the care used in operation and on the attention paid to such factors as hydraulic heads and air bubbles in connecting tubing. A realistic estimate is 0.03 db.

The estimated accuracy and precision of the current meter and tide-gauge sensors are tabulated in Table 2.

Table 3

Estimated Accuracy and Precision of Measurement

Instrument	Parameter	Accuracy	Precision	Resolution
RCM4	Speed (cm/s)	±2%	±7%	.05 cm/s
RCM4 (hose)	Direction (°T)	±3°	±7°	0.4°
RCM4 (pipe)	Direction (°T)	±30°	±16°	0.4°
RCM4	Temperature (°C)	±.005	±.005	0.005
RCM4	Conductivity Ratio	±.0025	±.0008	0.00016
TG4/WLR5A	Pressure (db)	±0.03db	±.005db	0.001%fs

4. DATA PROCESSING

The first stage in processing the current meter data was the translation of the information from the original one-quarter inch magnetic tape onto a computer-compatible nine-track magnetic tape. This process was done at the Institute of Ocean Sciences using an HP2100 computer. The data were then read into the Institute's Univac 1100/60 computer for editing. The editing procedure involved timing checks, the truncation of irrelevant pre- and post-deployment data, and the replacement of occasional spurious measurements, or "spikes". Calibration formulae were then applied to the "N" numbers to produce values of the designated parameters, usually speed (cm/sec), direction (degrees True), conductivity ratio, temperature, and sometimes pressure. Salinity and density were then calculated. Salinity was calculated using the Practical Salinity Scale 1978 (Lewis, 1981). Density was presented as sigma-t (σ_t), from the relationship,

$$\sigma_t = (\text{density } (\text{gm/cm}^3) - 1) \times 10^3.$$

After the data had been converted to real values, they were stored on magnetic tape. Each file on a tape contains information from one instrument. The files begin with a header which indicates such things as instrument number, station location, and station designation. These are followed by eleven channels of calibrated data as follows:

channel 1 - time
2 - speed
3 - direction
4 - high resolution temperature
5 - salinity
6 - pressure
7 - conductivity ratio
8 - sigma-t
9 - low resolution temperature
10 - time code generator
11 - voltage reference

All channels were not always used in each instance.

Similar procedures were used to process the tide gauge data.

5. DATA PRESENTATION

The calibrated and corrected current meter data are presented in the Appendix as time series plots of current speed, direction, temperature, and salinity. Superimposed on the speed and direction traces with a heavier pen are low-pass filtered values of the same (tidal signal removed). One month of data is displayed per page.

For the tide-gauge measurements, only one month of representative data is shown.

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APPENDIX

Recording instrument data index and time-series plots.

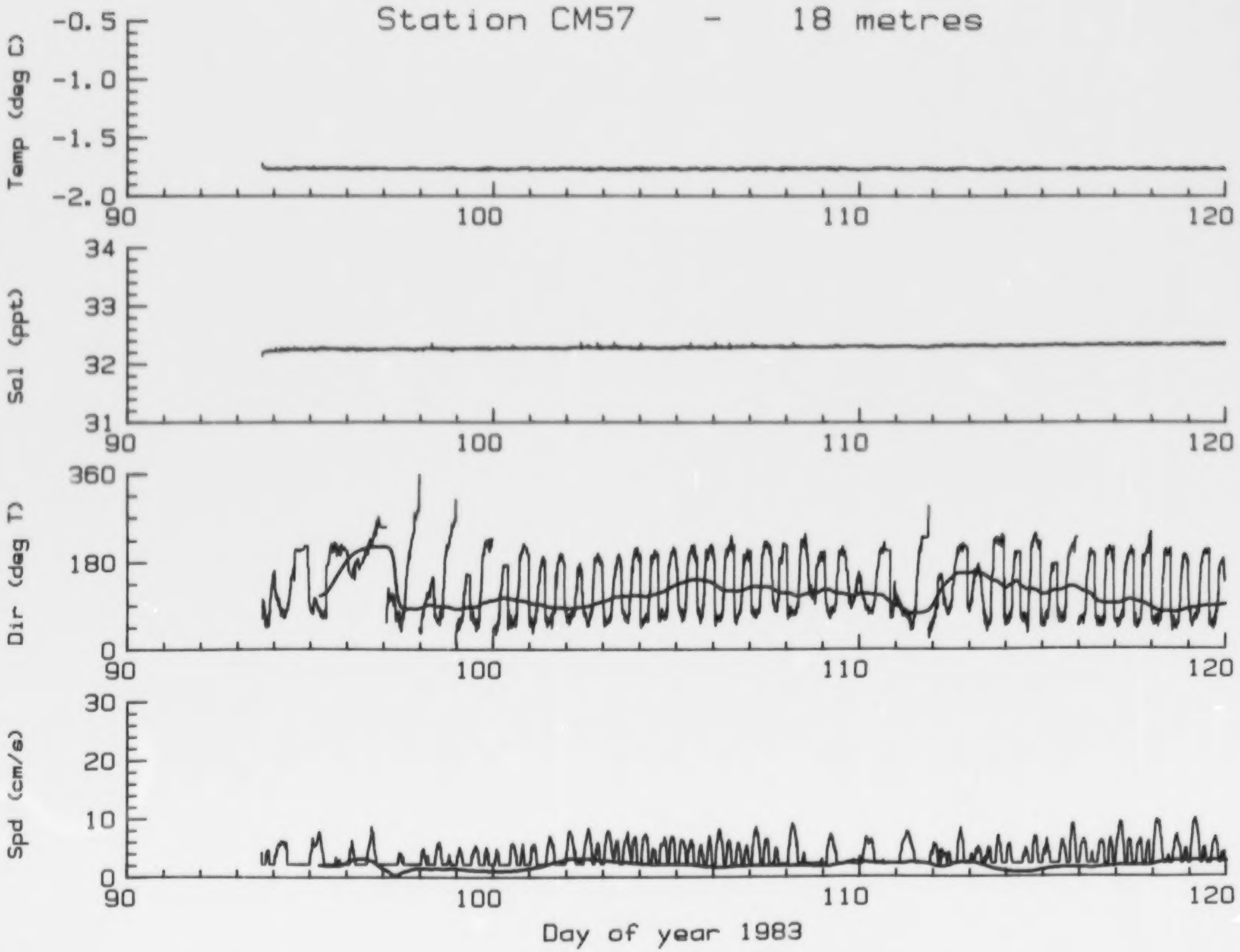
RECORDING INSTRUMENT DATA INDEX

CURRENT METERS

STATION	PAGE	STATION	PAGE	STATION	PAGE
CM57	23	CM71- 18m	34	CM81	70
CM58	25	CM71- 73m	36	CM82	73
CM62	27	CM71- 123m	50	CM83	76
CM63	29	CM72	64	CM86	79
CM65	31	CM74	66	CM87	82
CM66	32	CM79	68		

TIDE GAUGES

STATION	PAGE
Cape Cockburn	84
Byam Martin Channel	84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-2.0
Sal (ppt)
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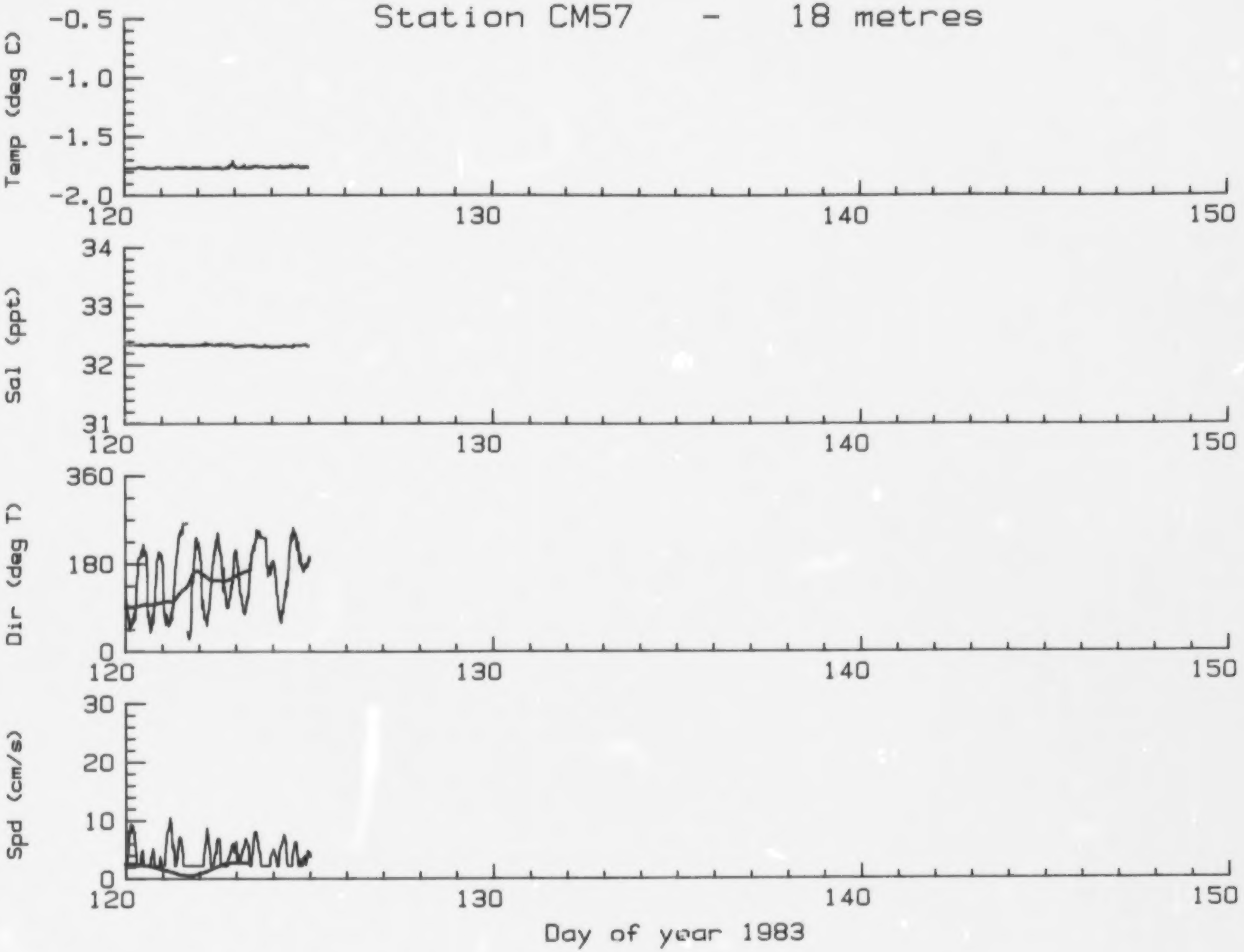
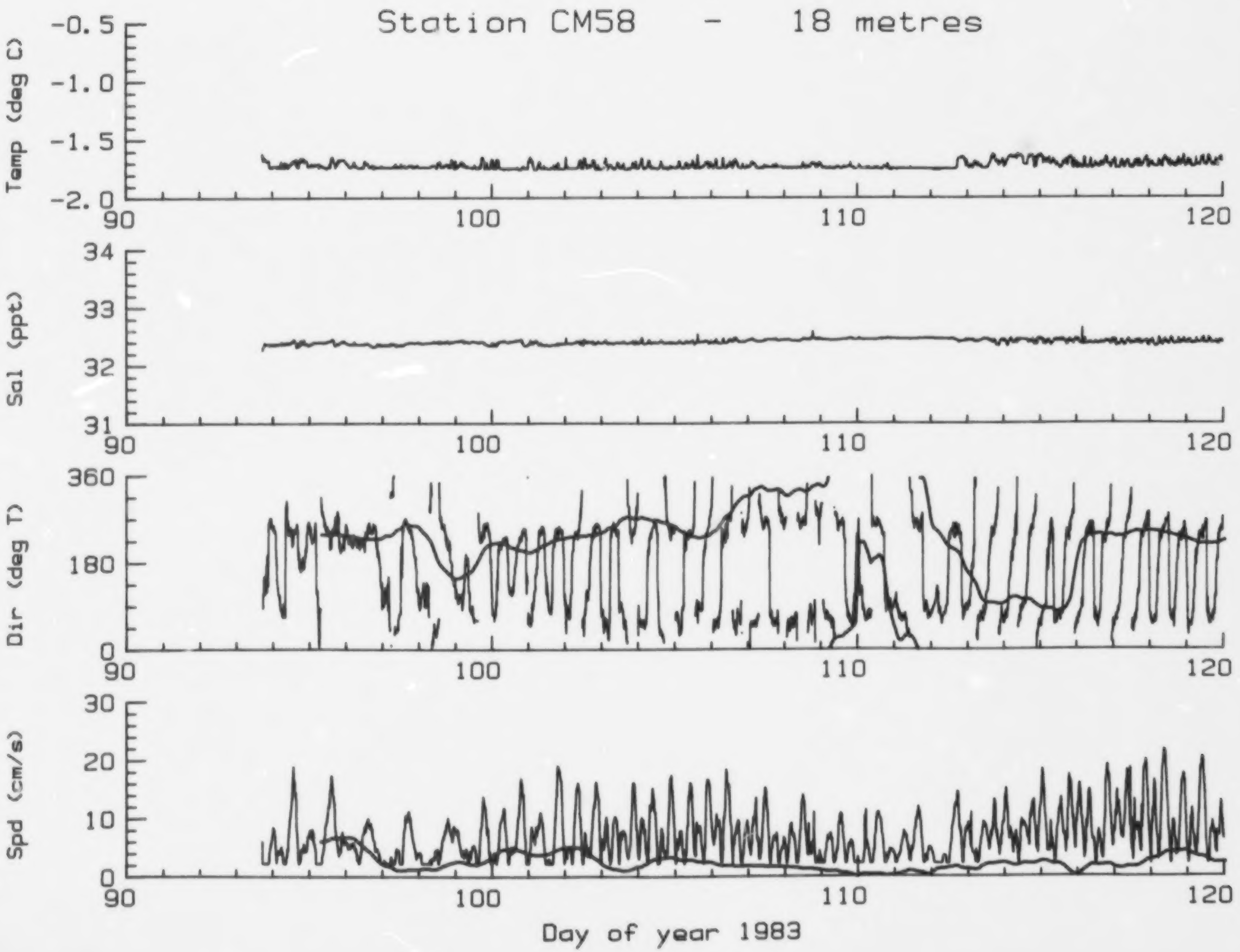
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1983

Station CM57 - 18 metres

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Sal (ppt)
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Dir (deg T)
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Spd (cm/s)
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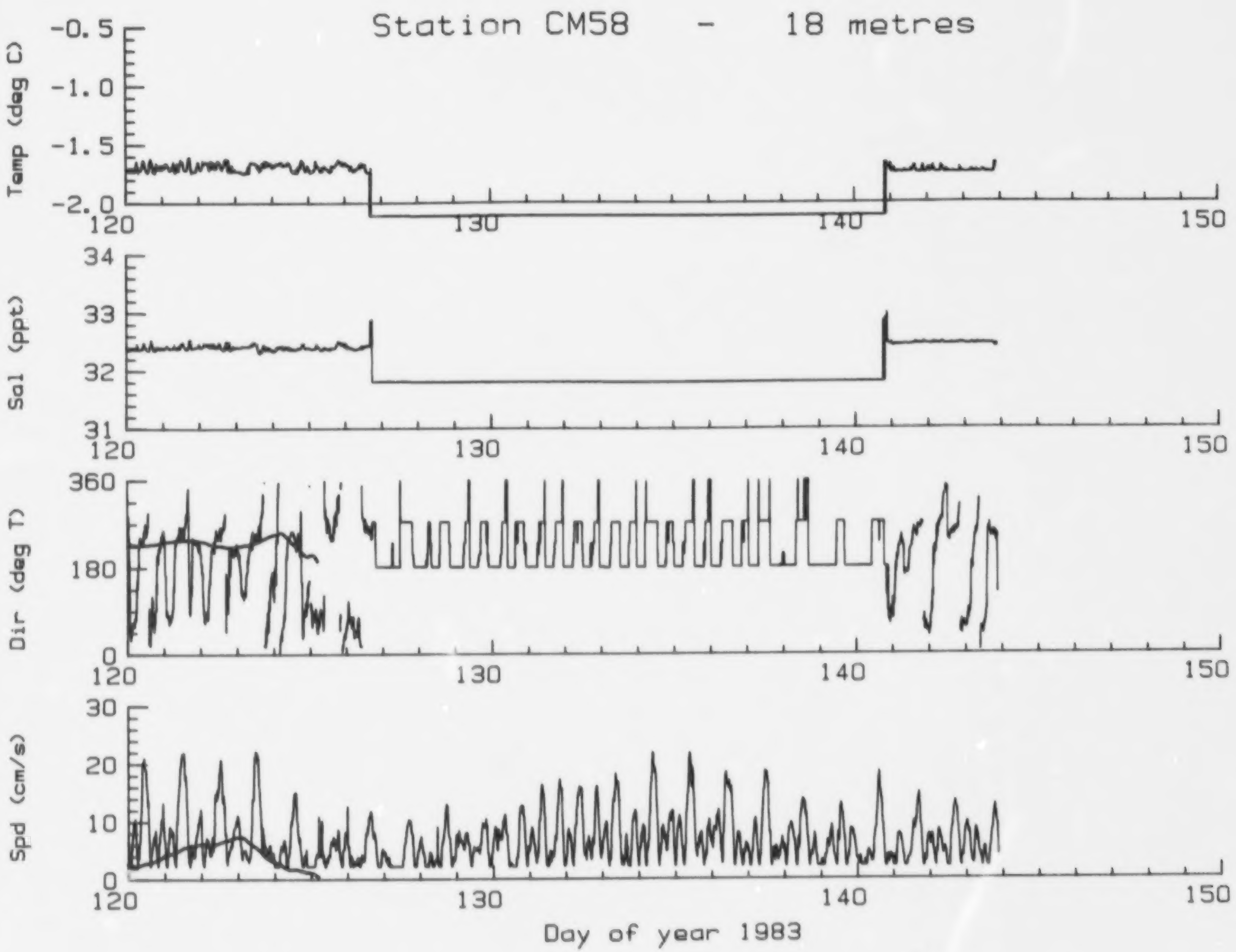
20
10
0
90
100
110
120
Day of year 1983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Spd (cm/s)
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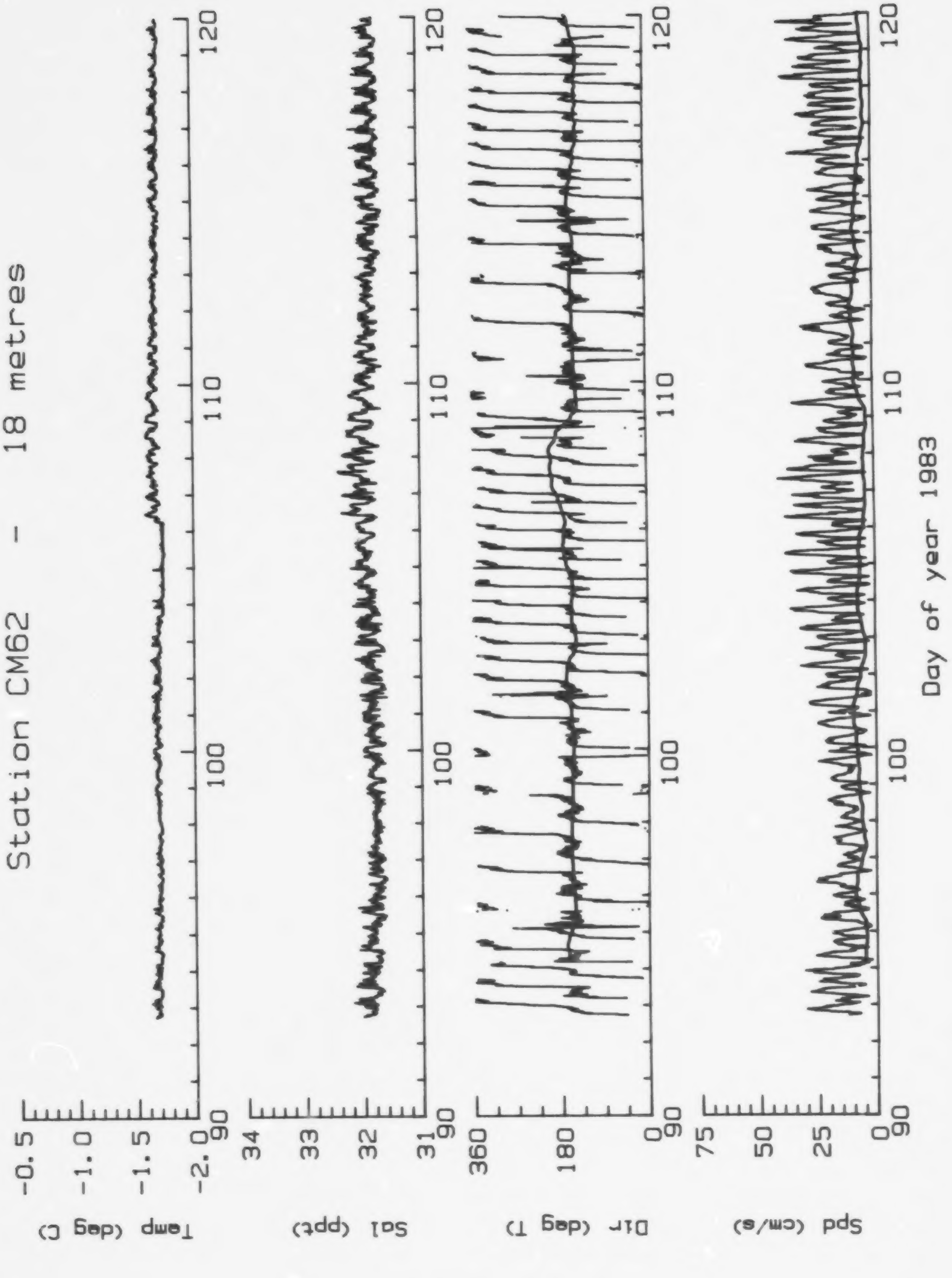
Day of year 1983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Dir (deg T)
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Spd (cm/s)
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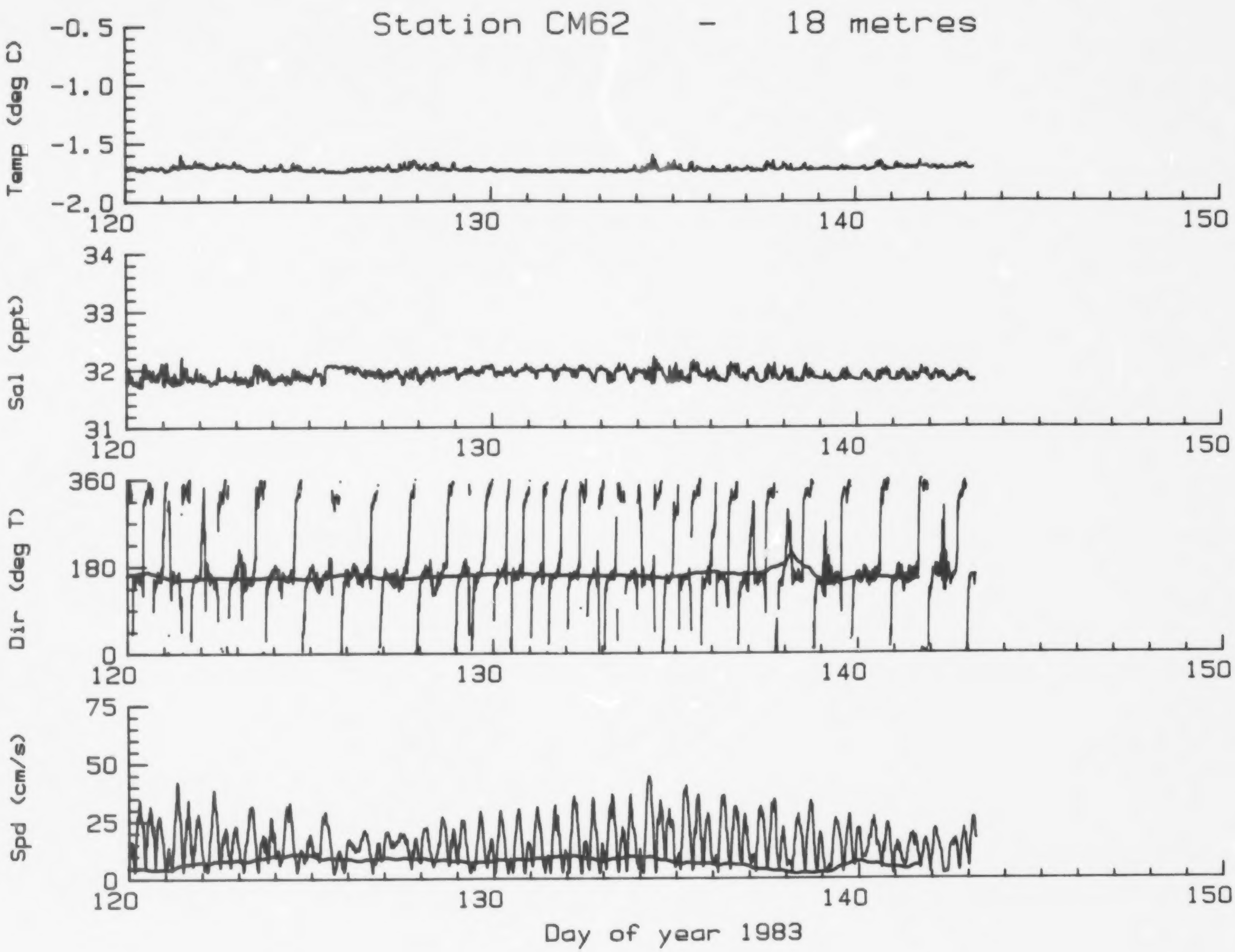
110
120
Day of year 1983



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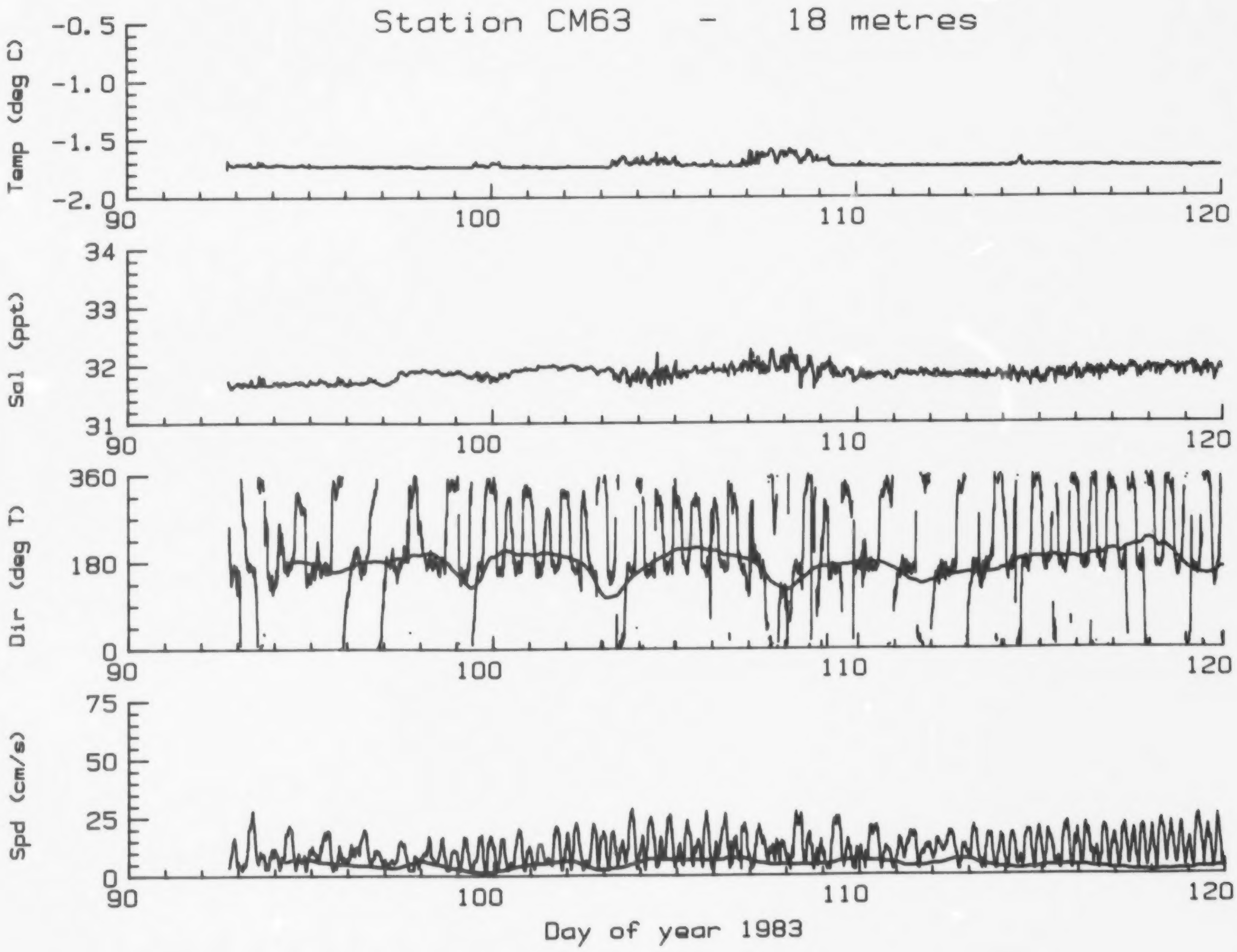
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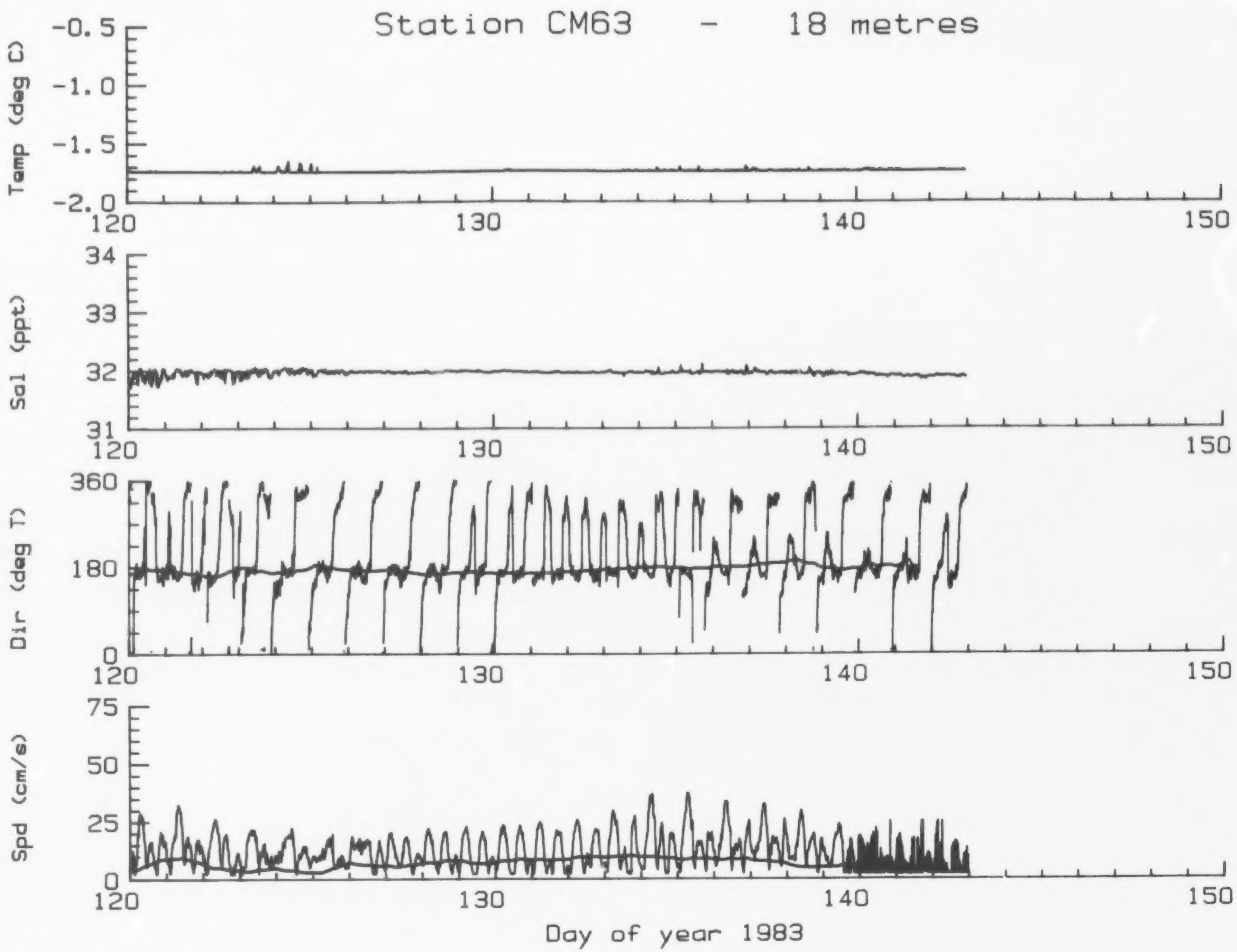
Day of year 1983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Spd (cm/s)
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140
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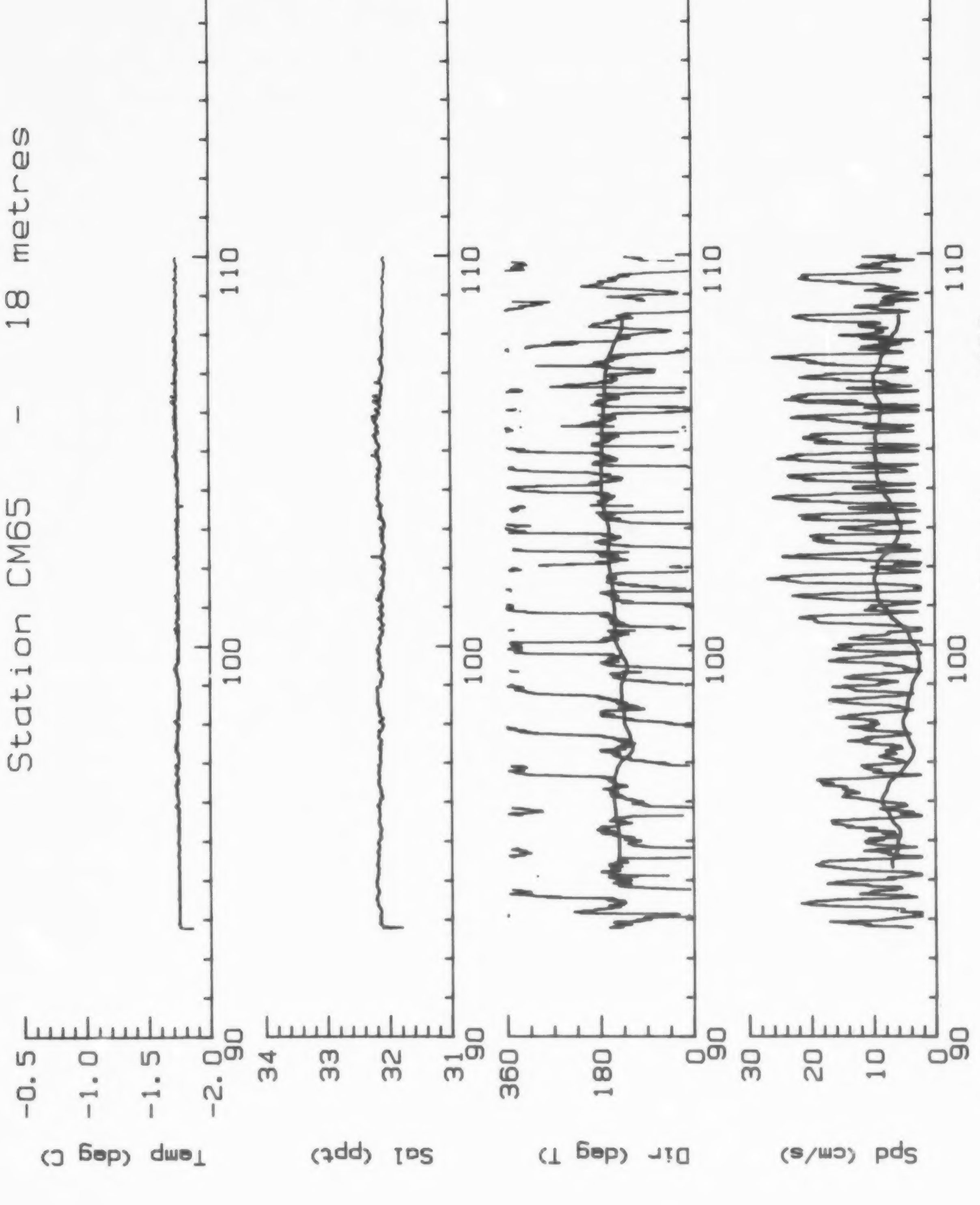
Day of year 1983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Spd (cm/s)
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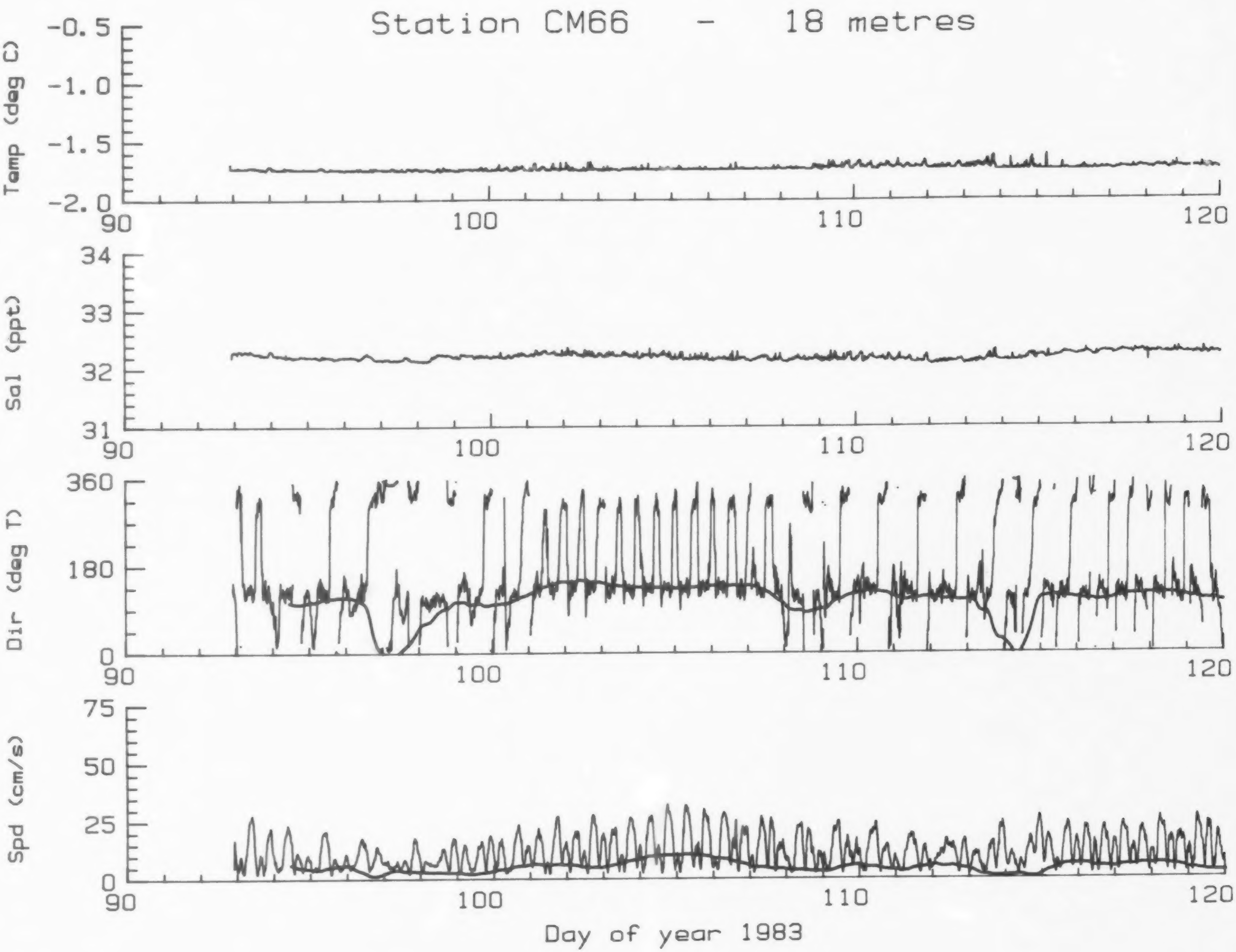
Day of year 1983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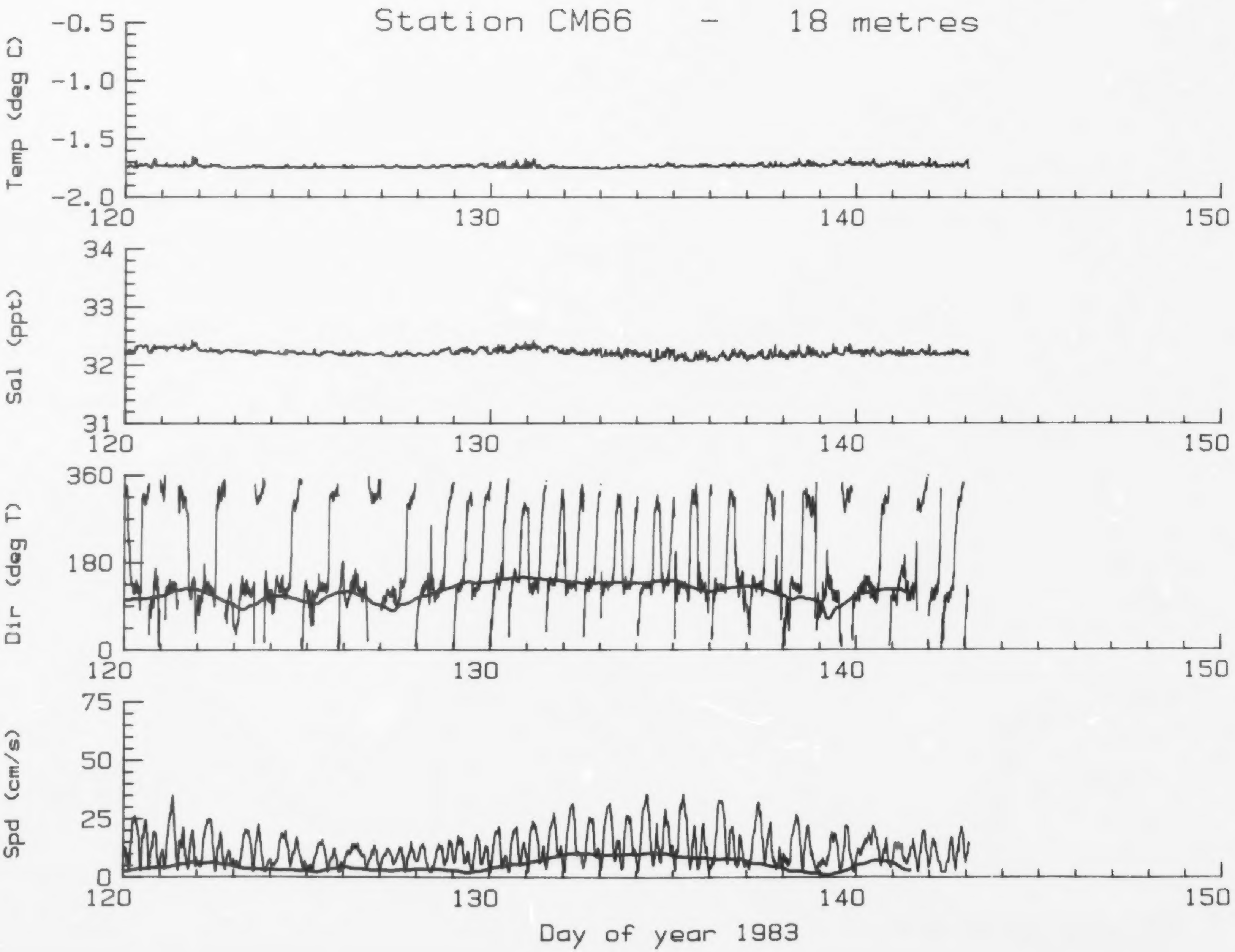
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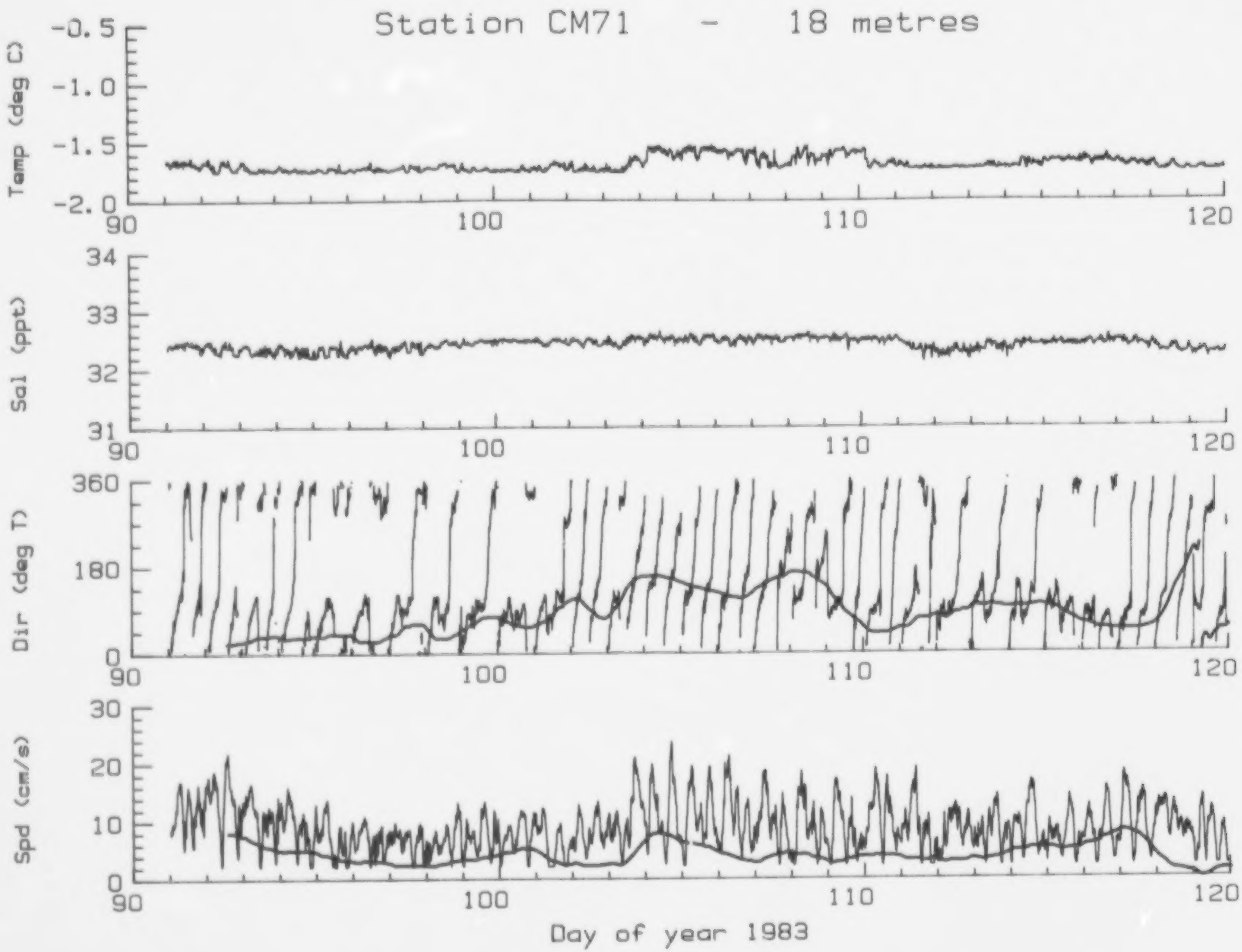
Day of year 1983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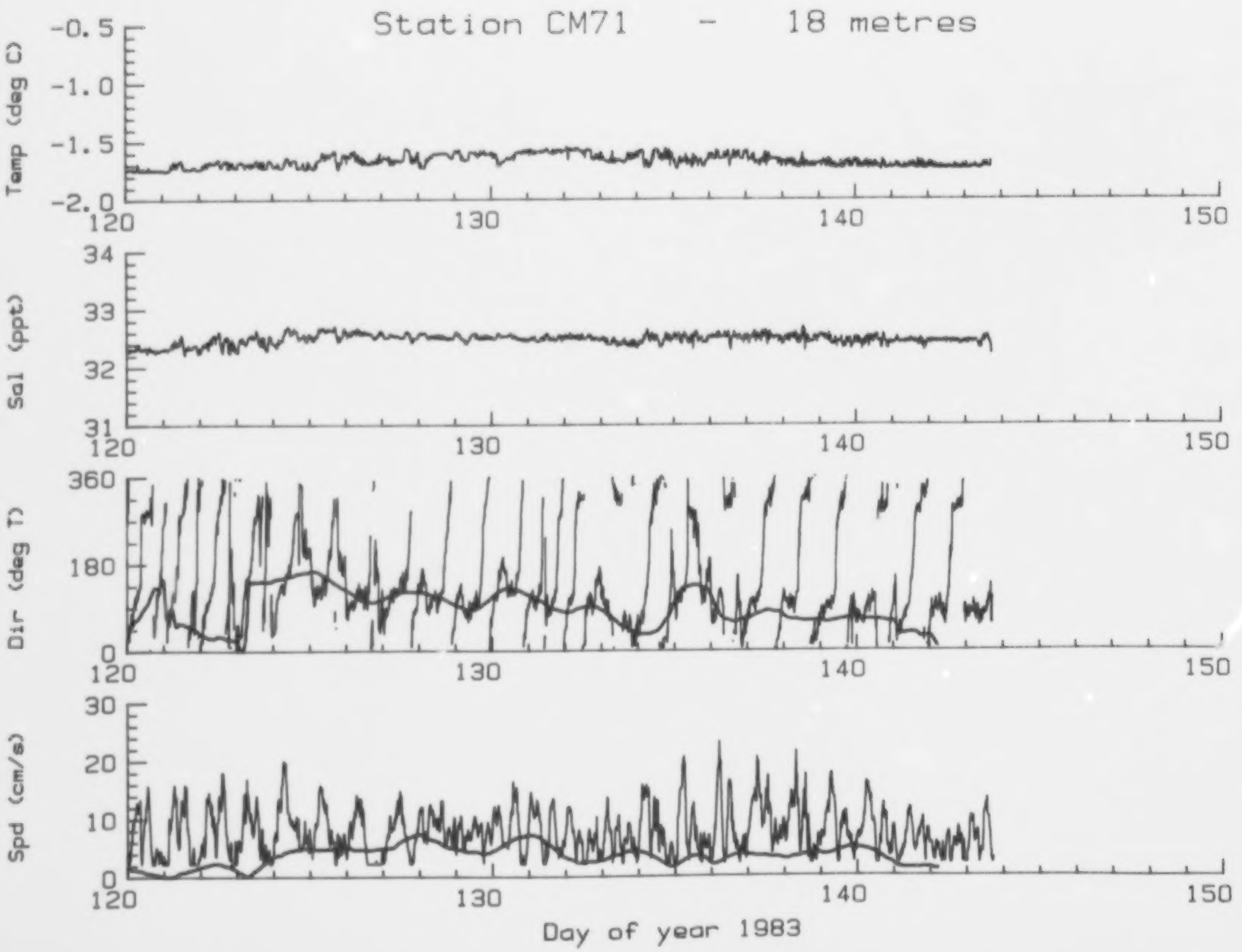
Day of year 1983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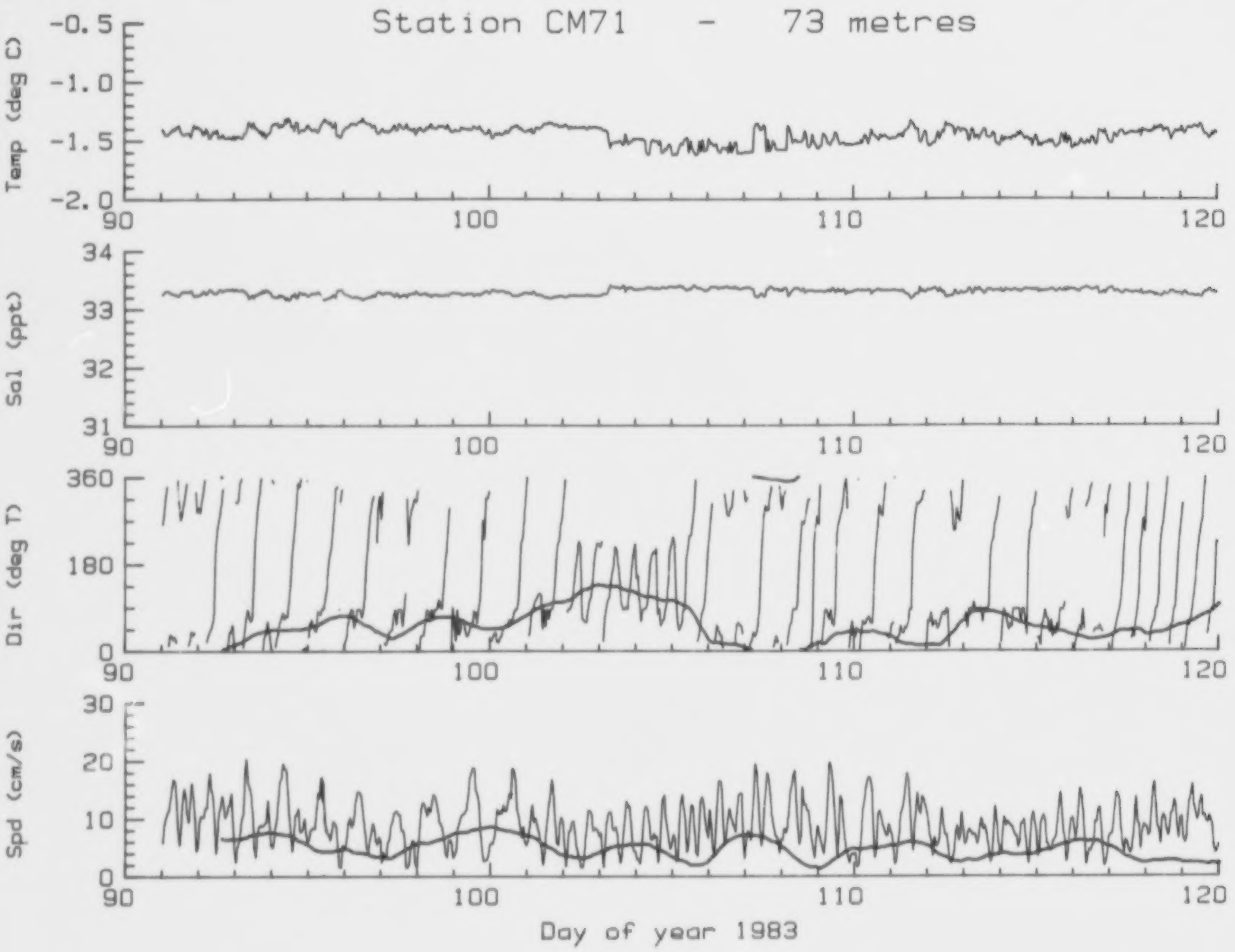
Day of year 1983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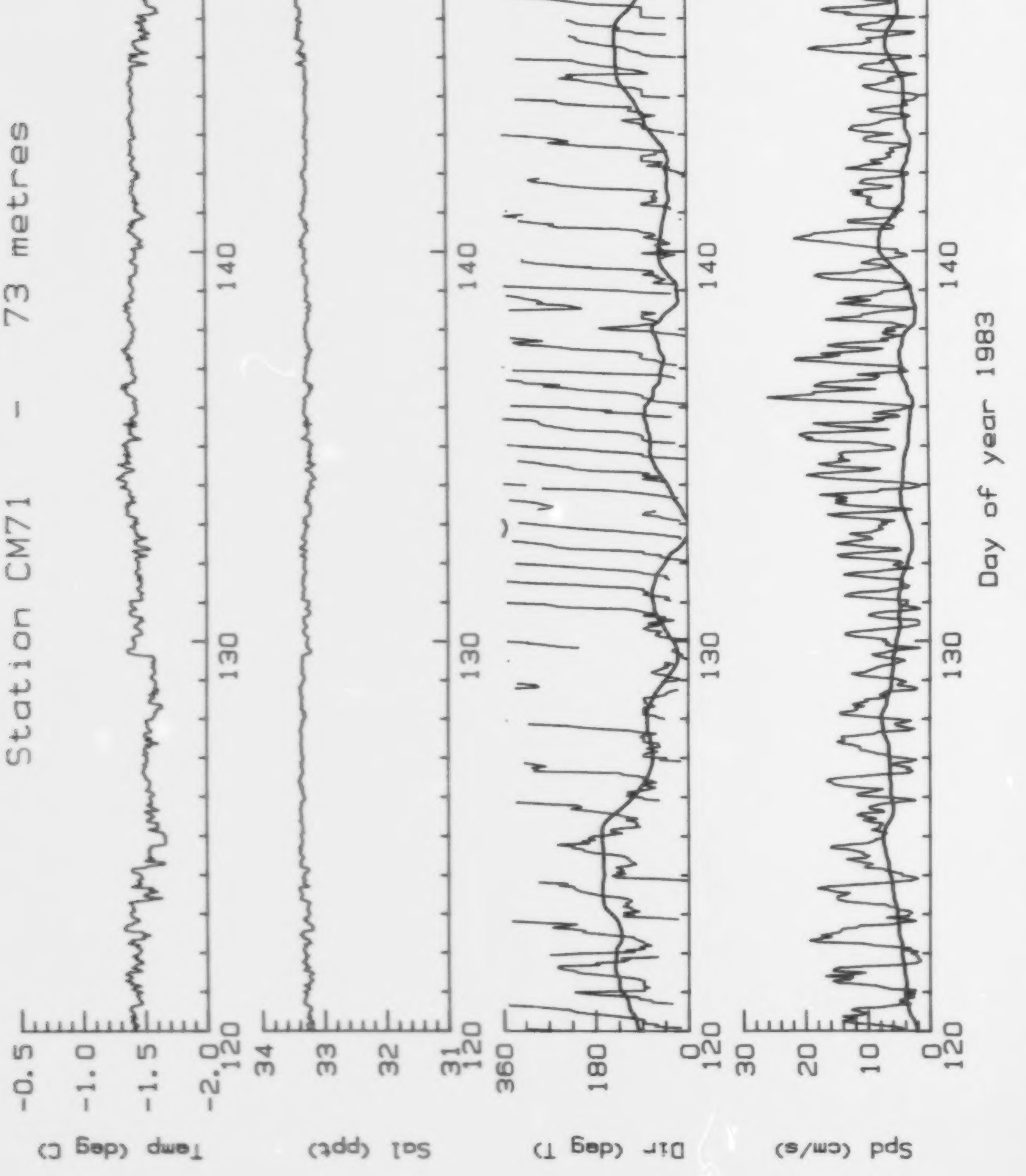
Day of year 1983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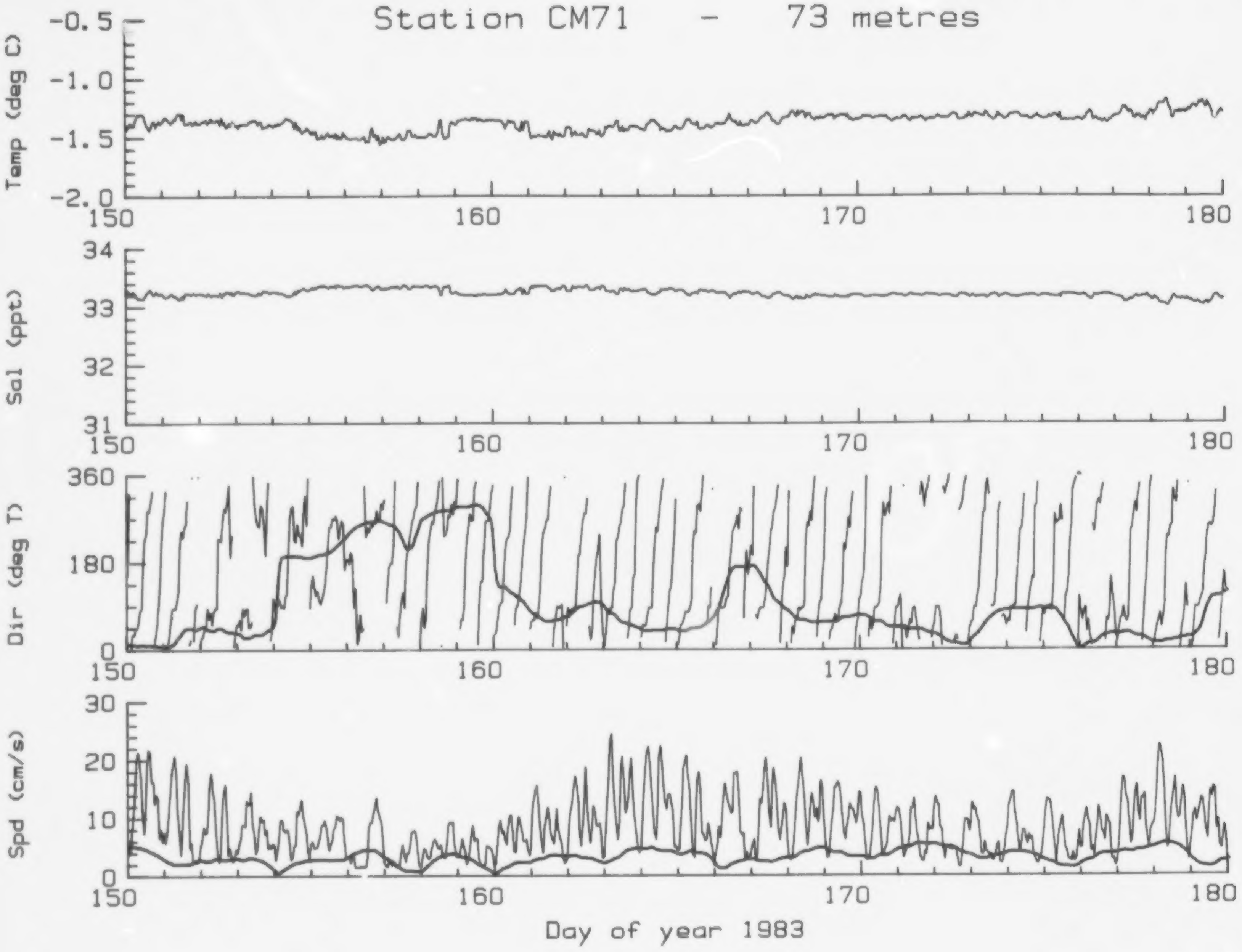
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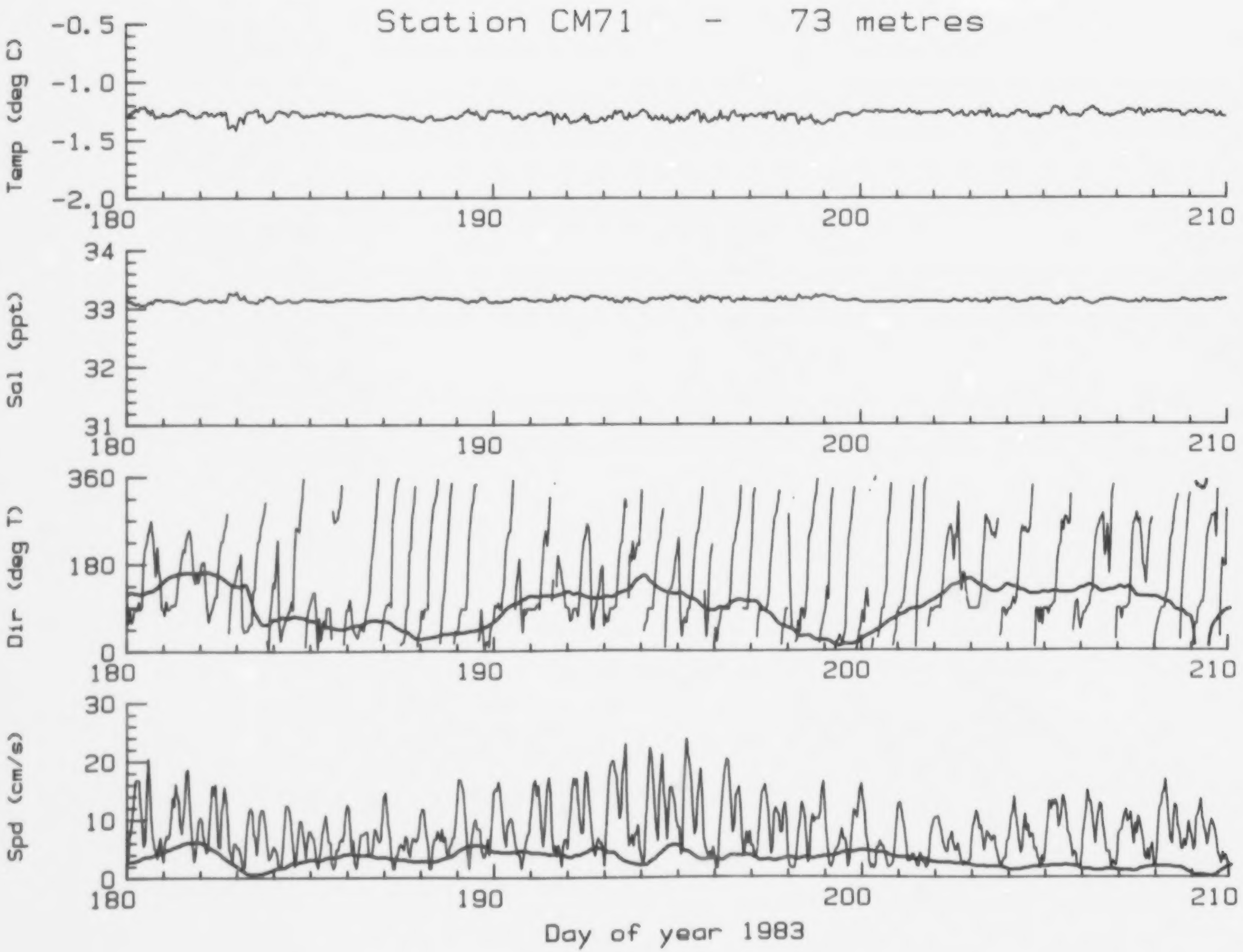
Day of year 1983



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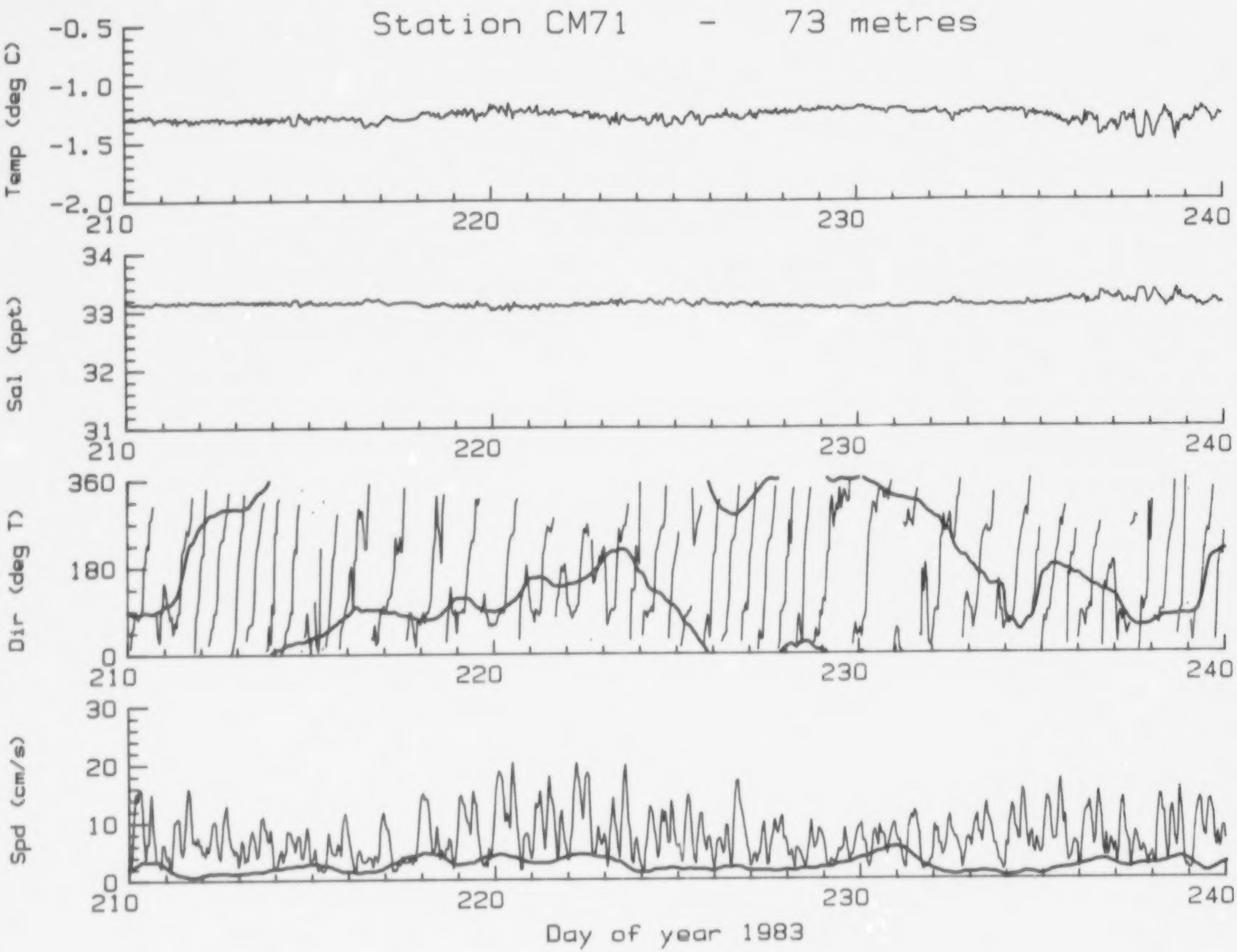
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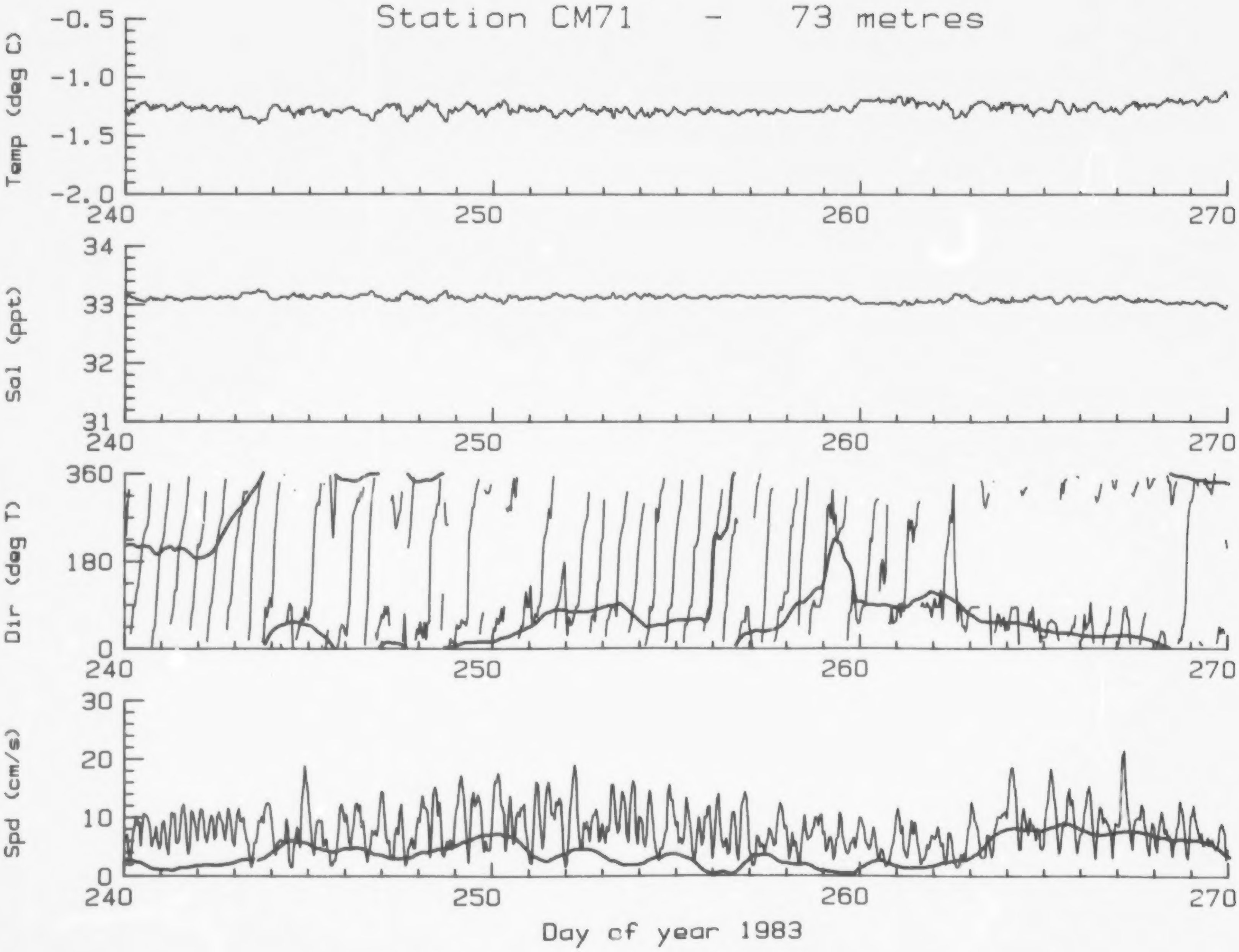
Day of year 1983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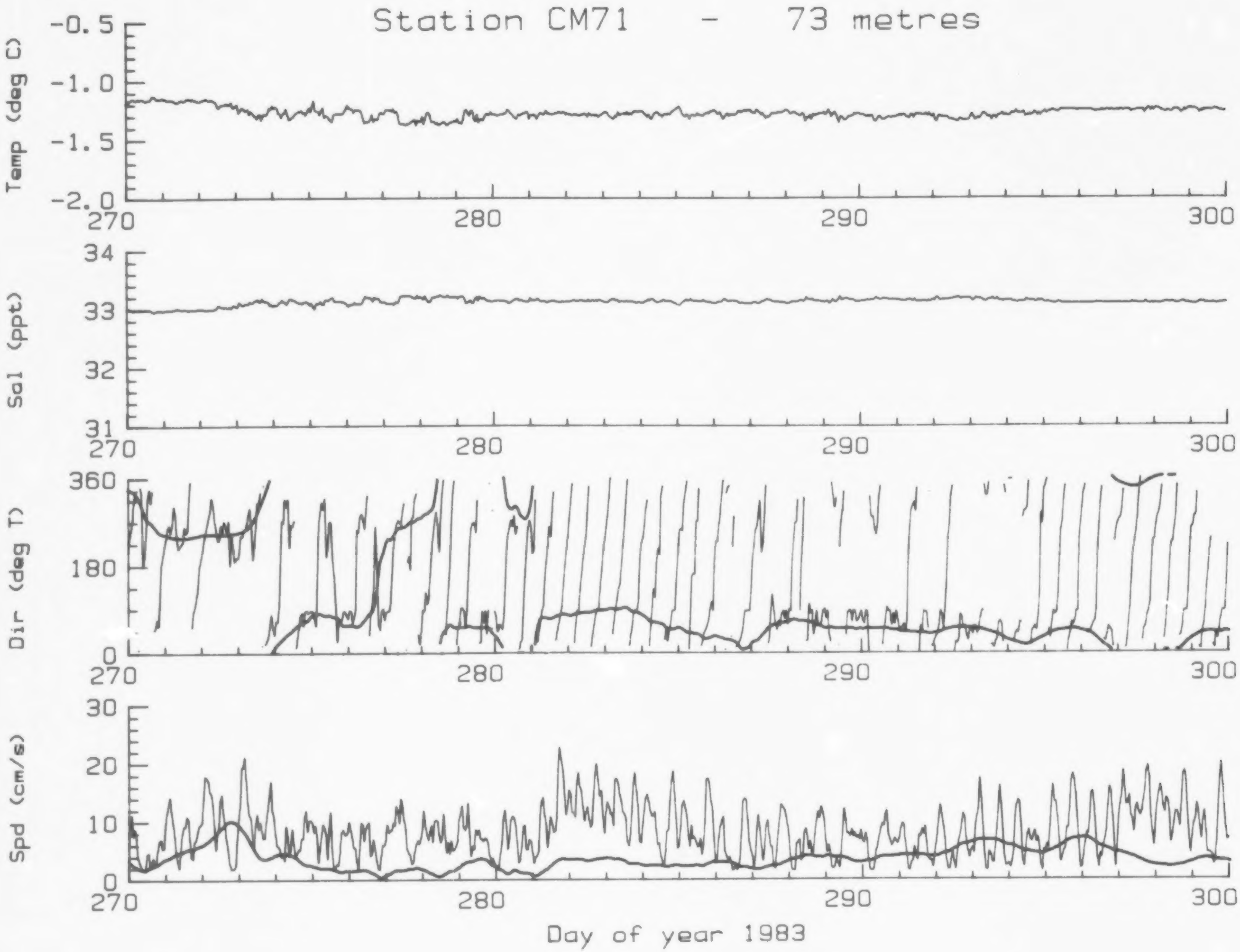
Day of year 1983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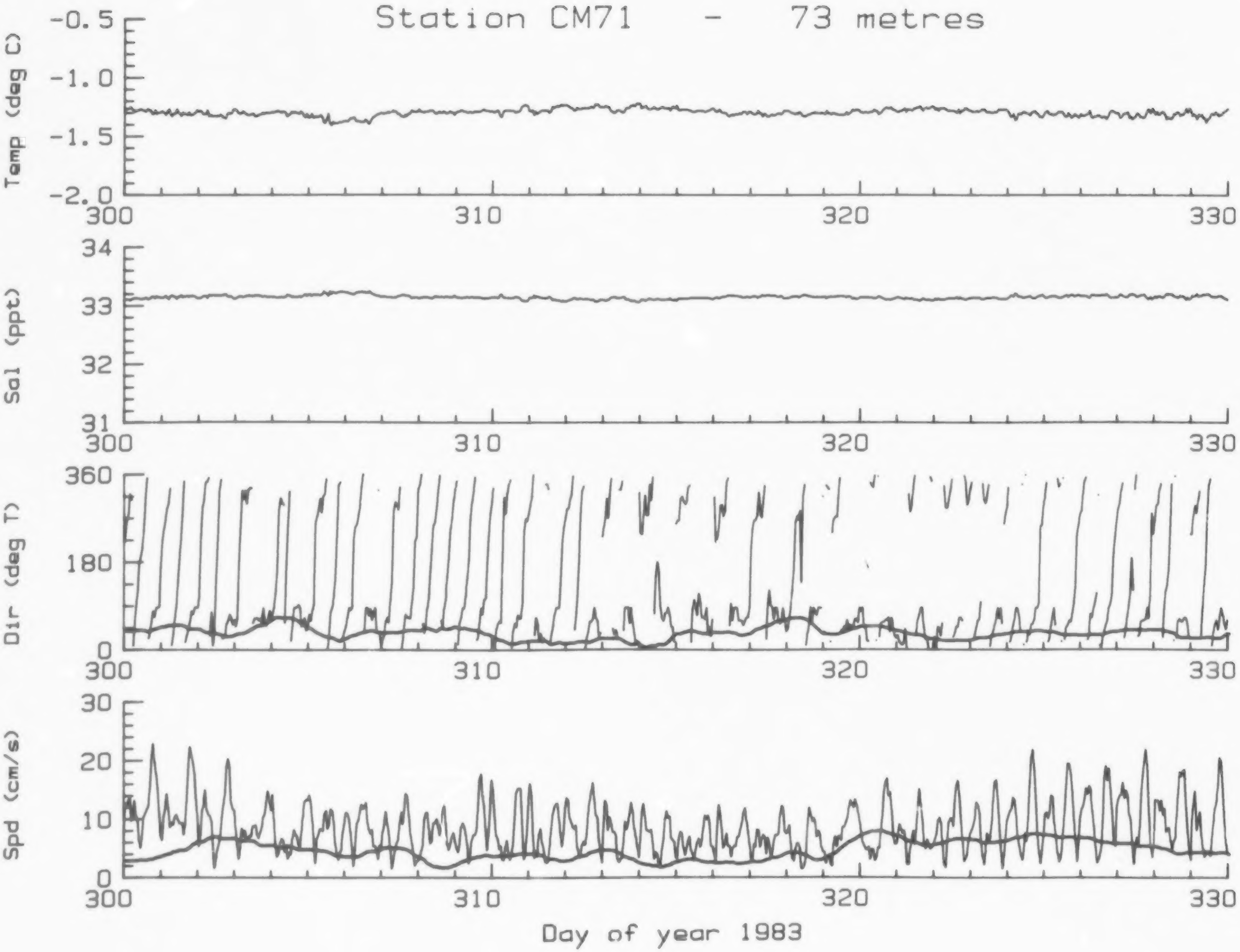
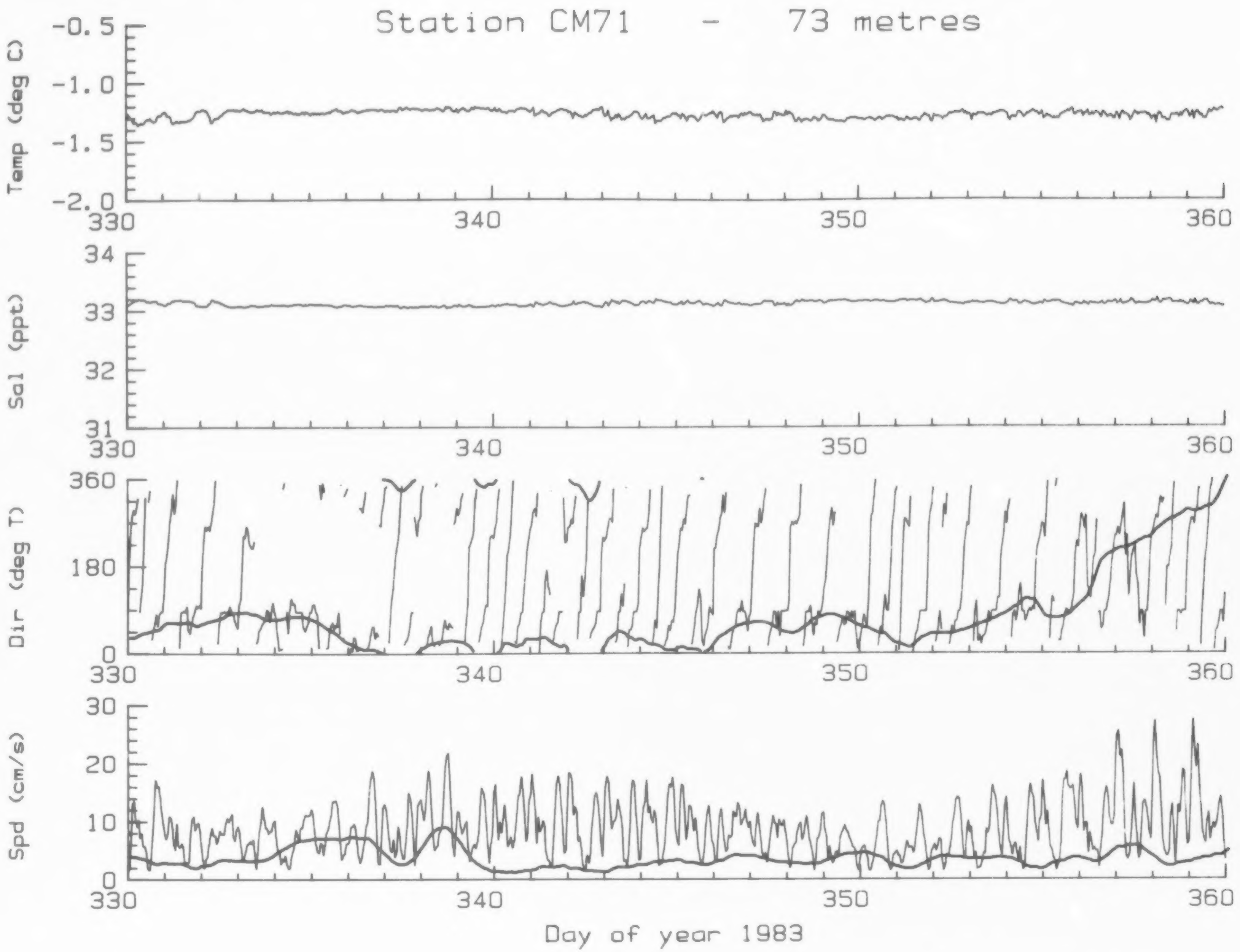
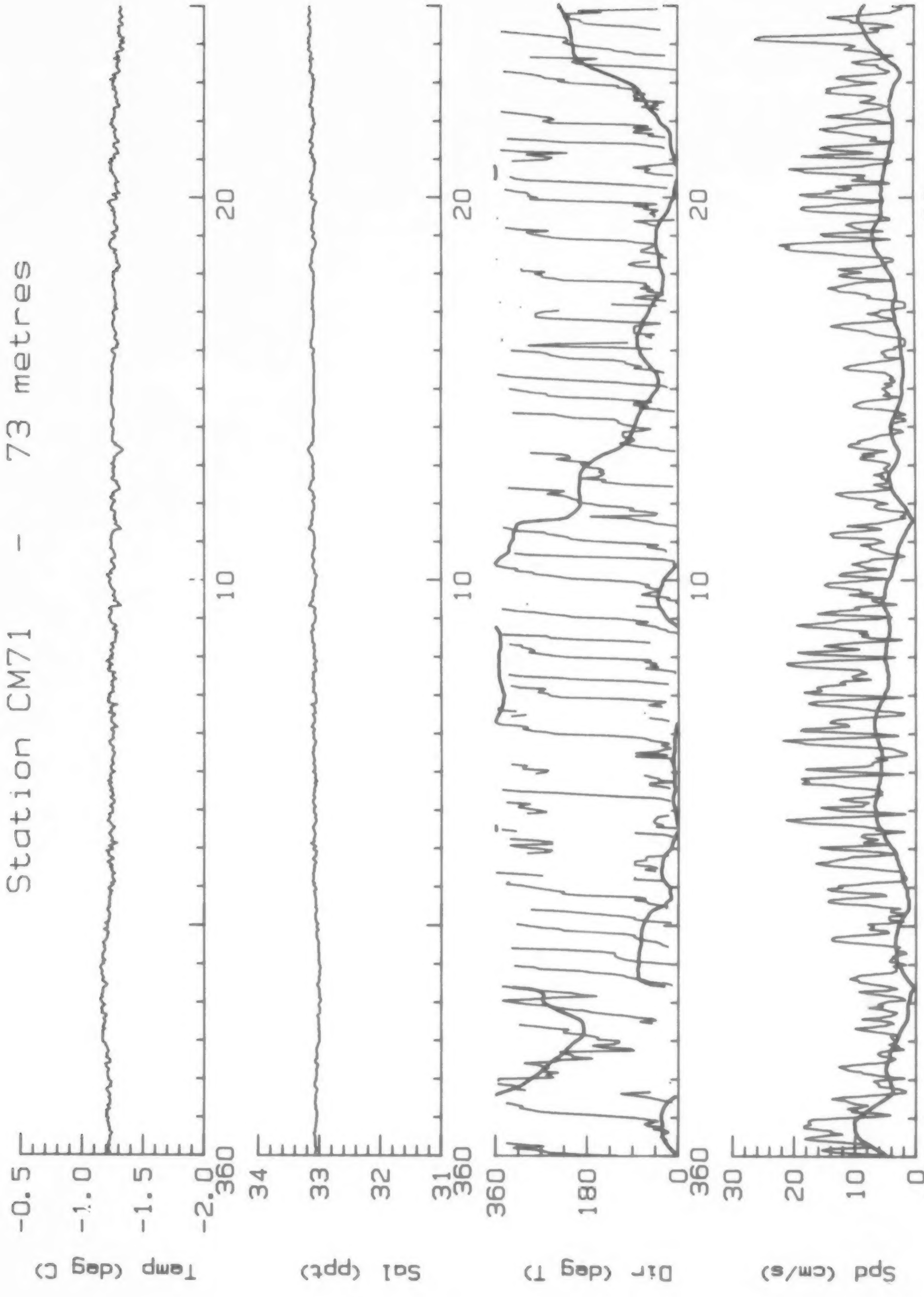
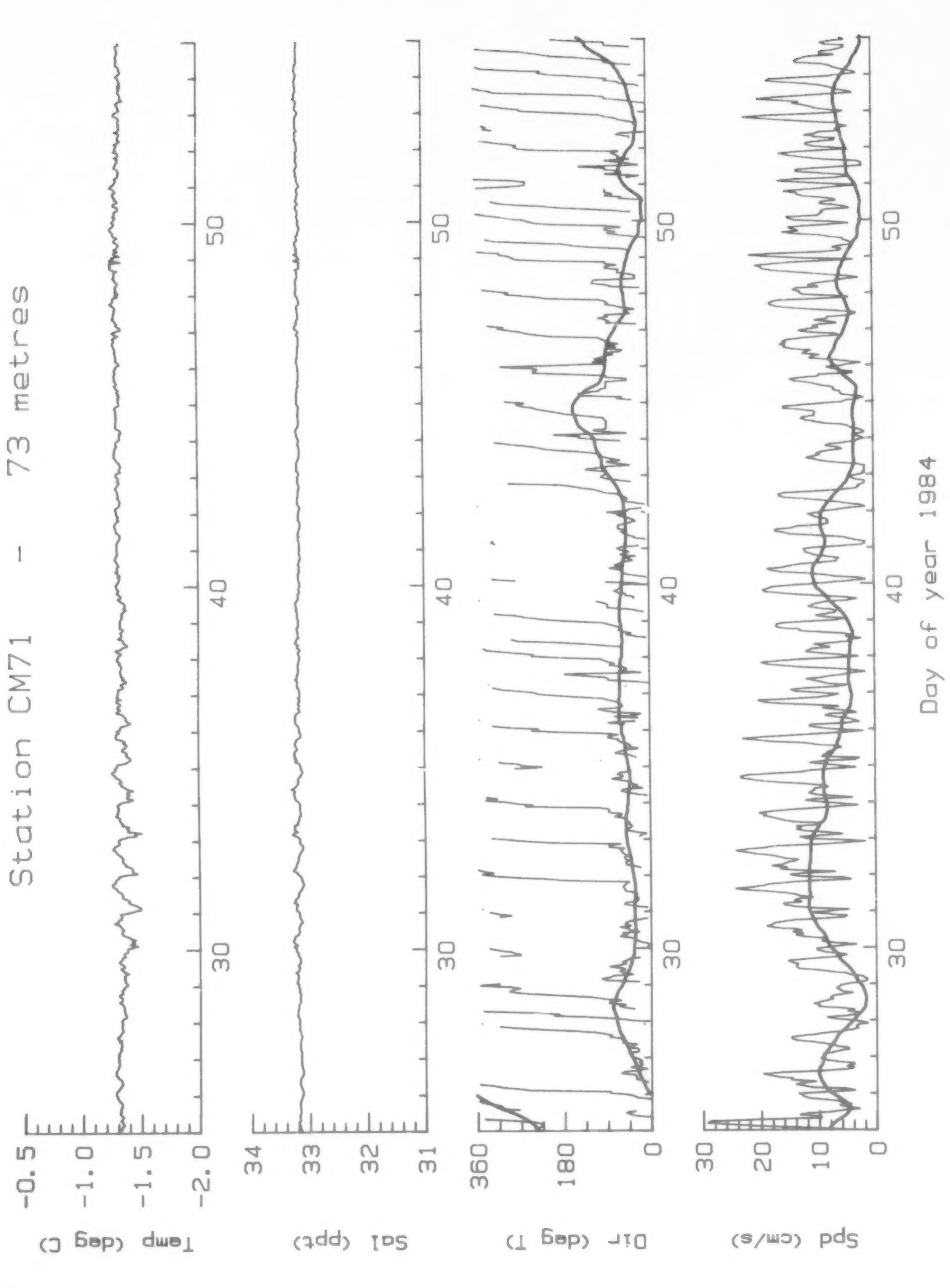
32
31
270
280
290
300
Dir (deg T)
360
180
0
270
280
290
300
Spd (cm/s)
30
20
10
0
270
280
290
300
Day of year 1983

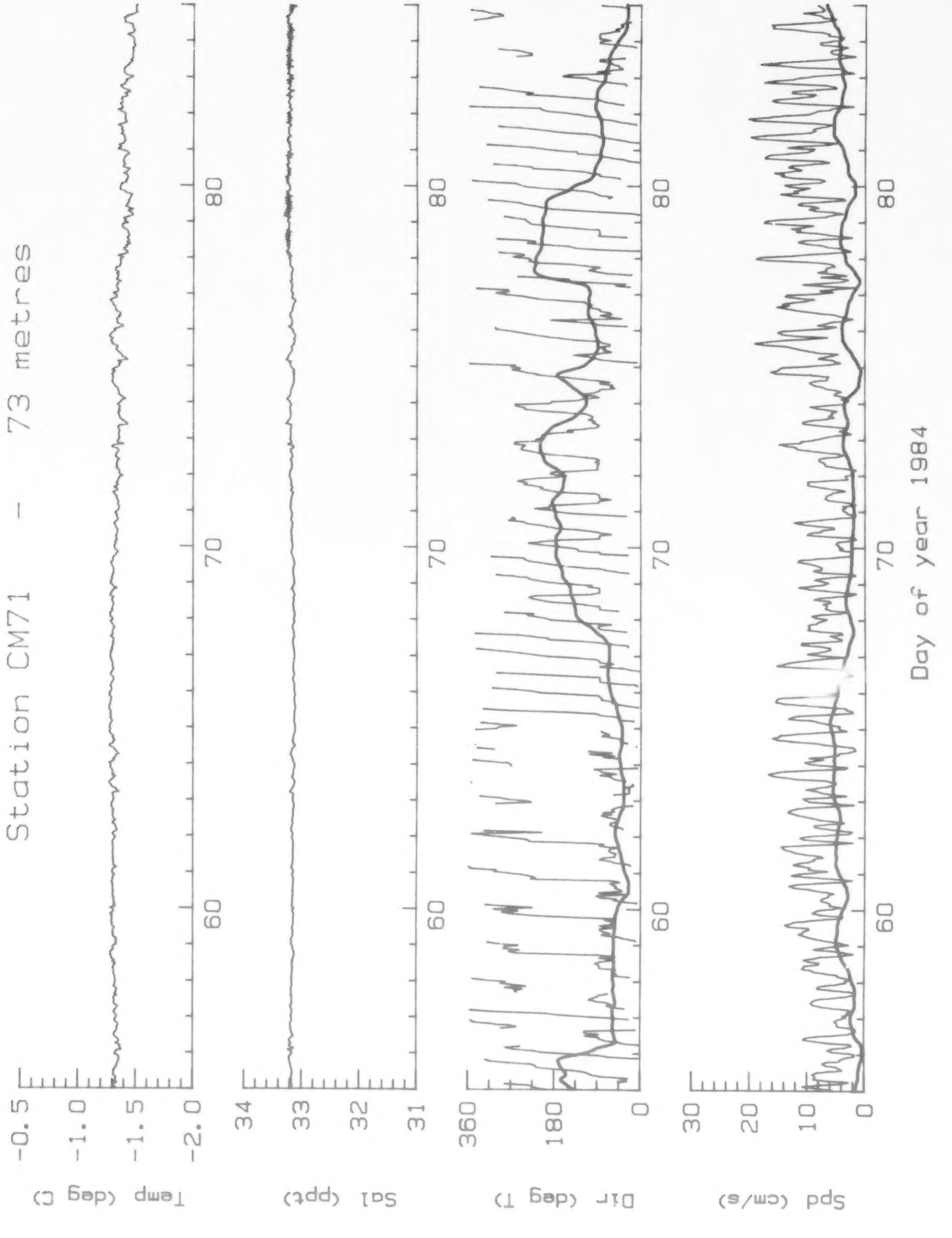

Station CM71 - 73 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
300
310
320
330
Day of year 1983

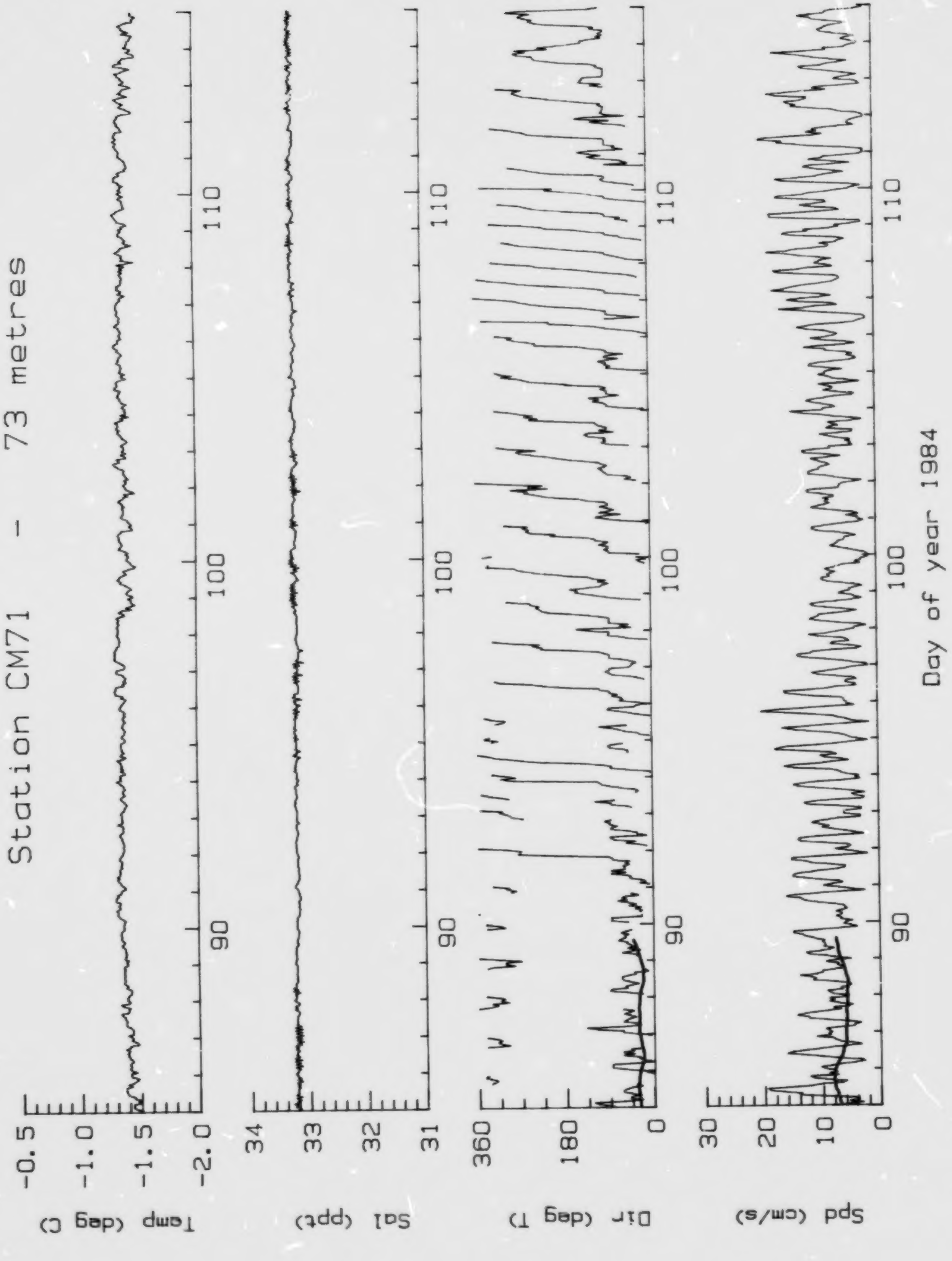

Station CM71 - 73 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
330
340
350
360
Day of year 1983



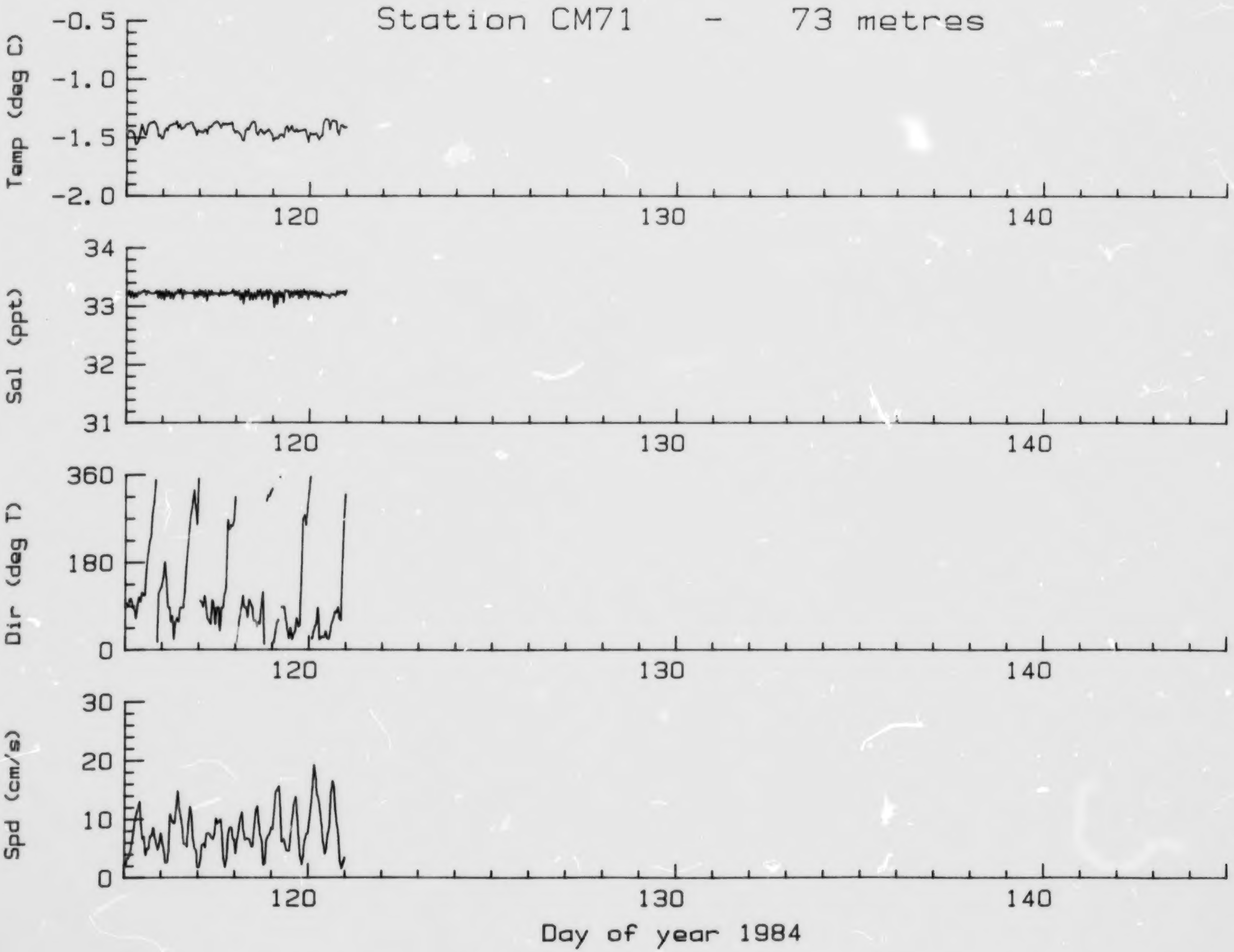
Station CM71 - 73 metres


Station CM71 - 73 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
30
40
50
Day of year 1984

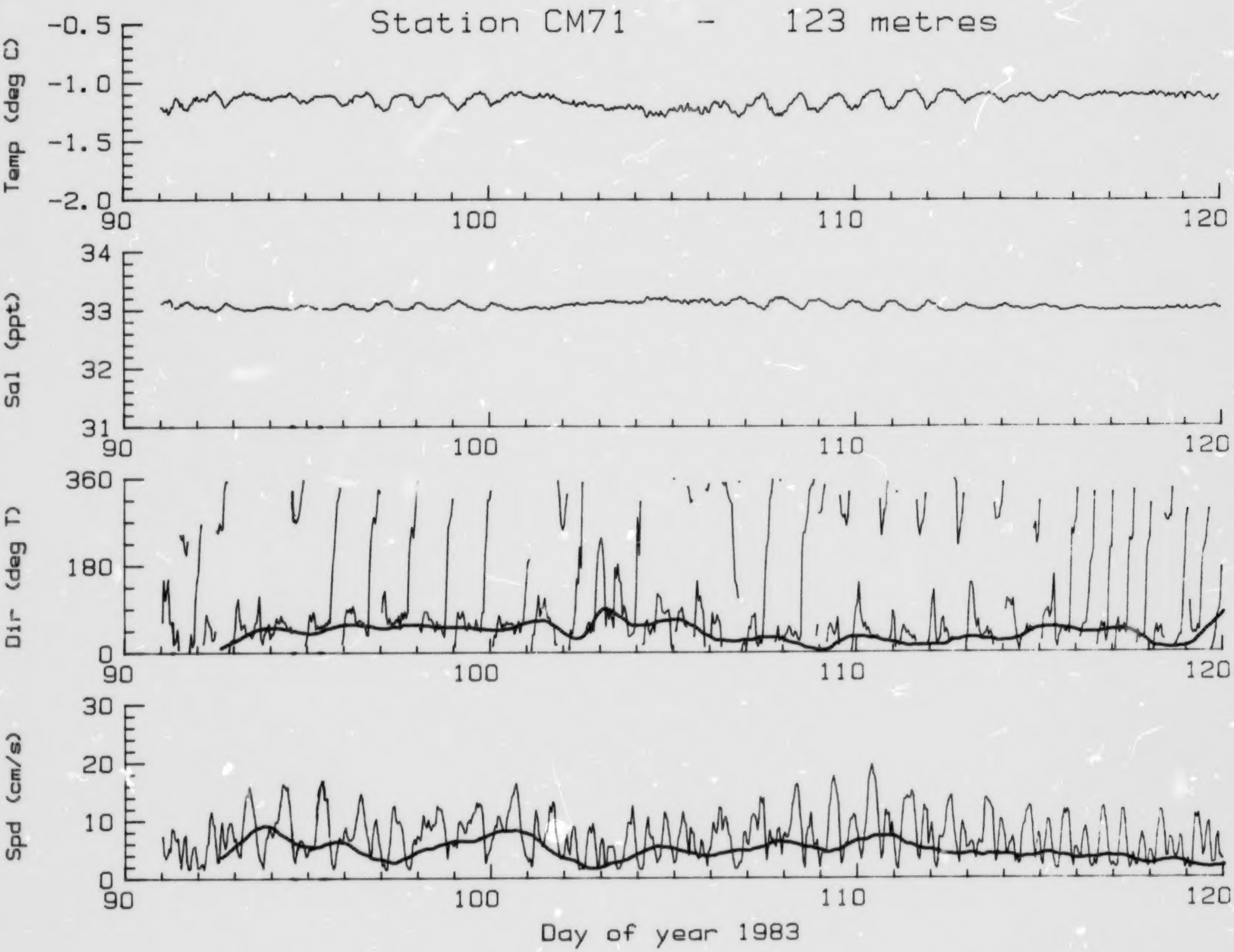

Station CM71 - 73 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
60
70
80
Day of year 1984

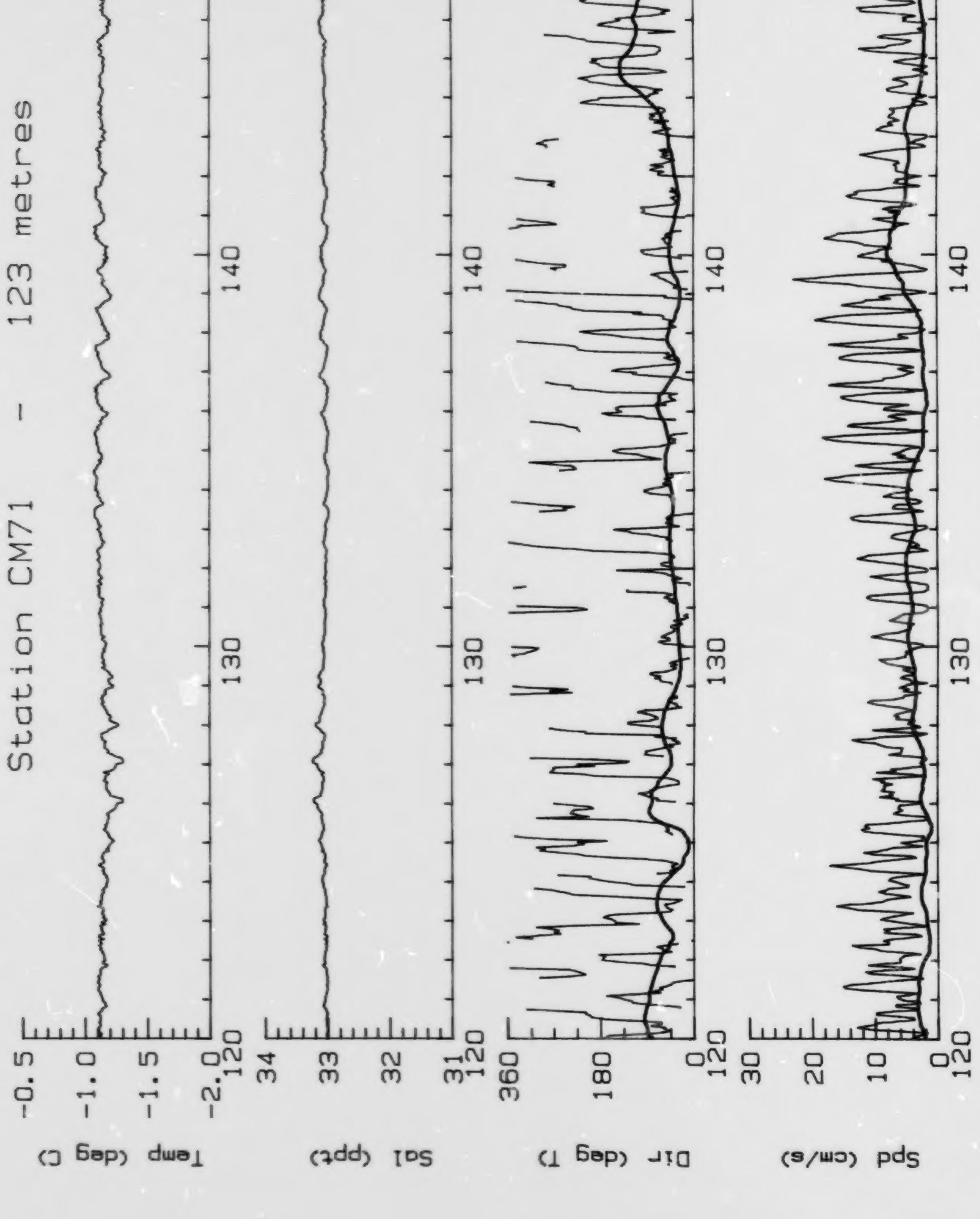


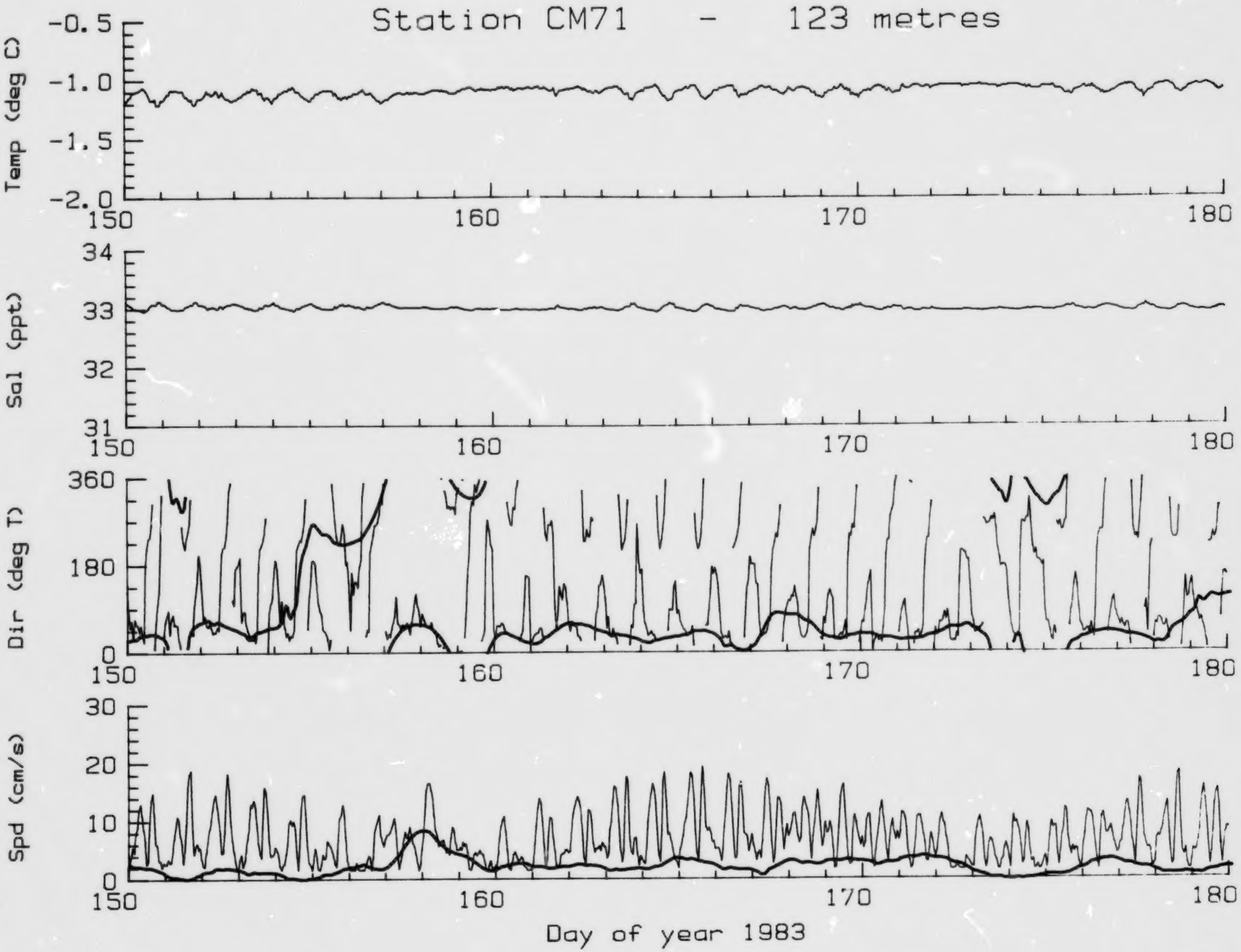
Station CM71 - 73 metres

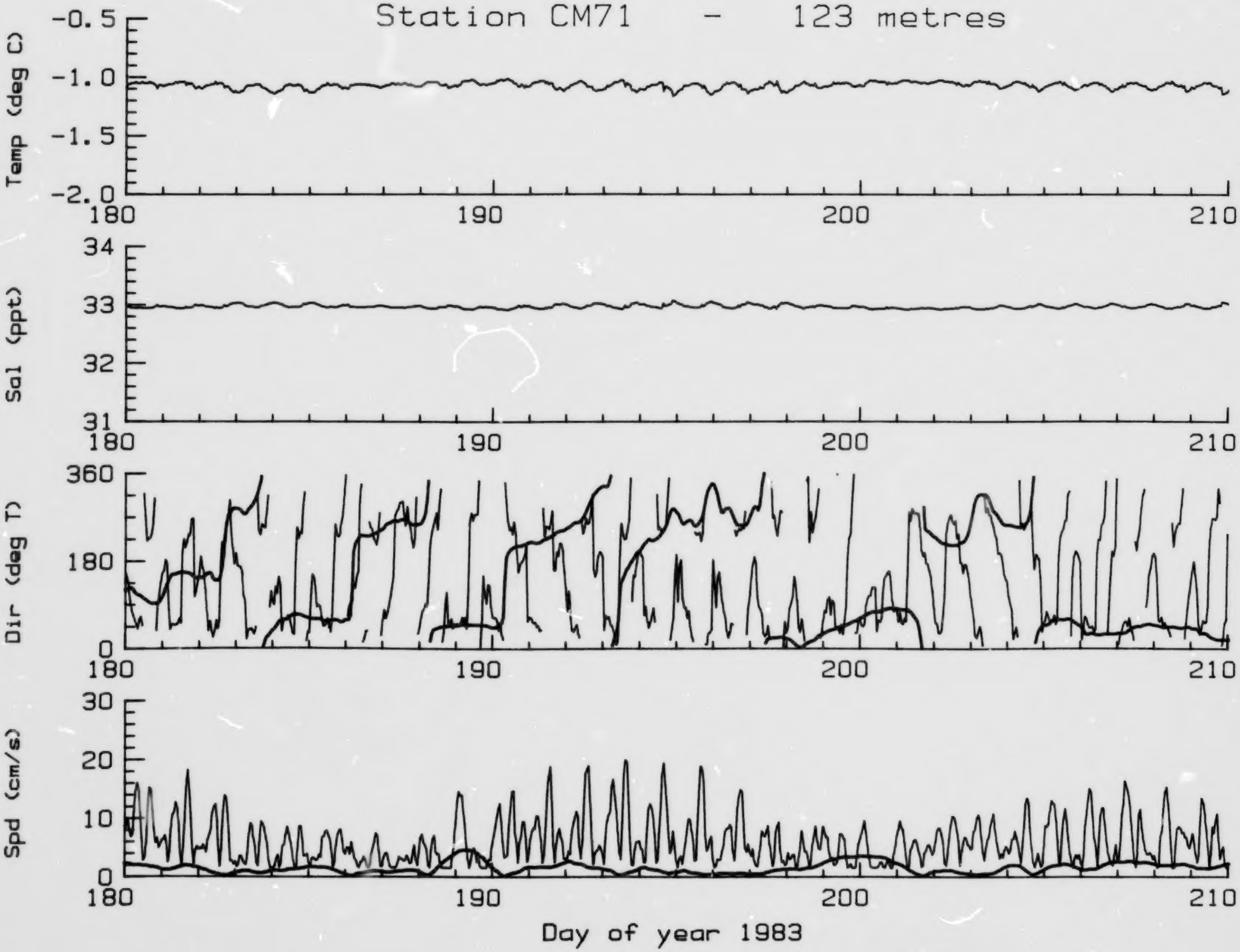


Station CM71 - 73 metres

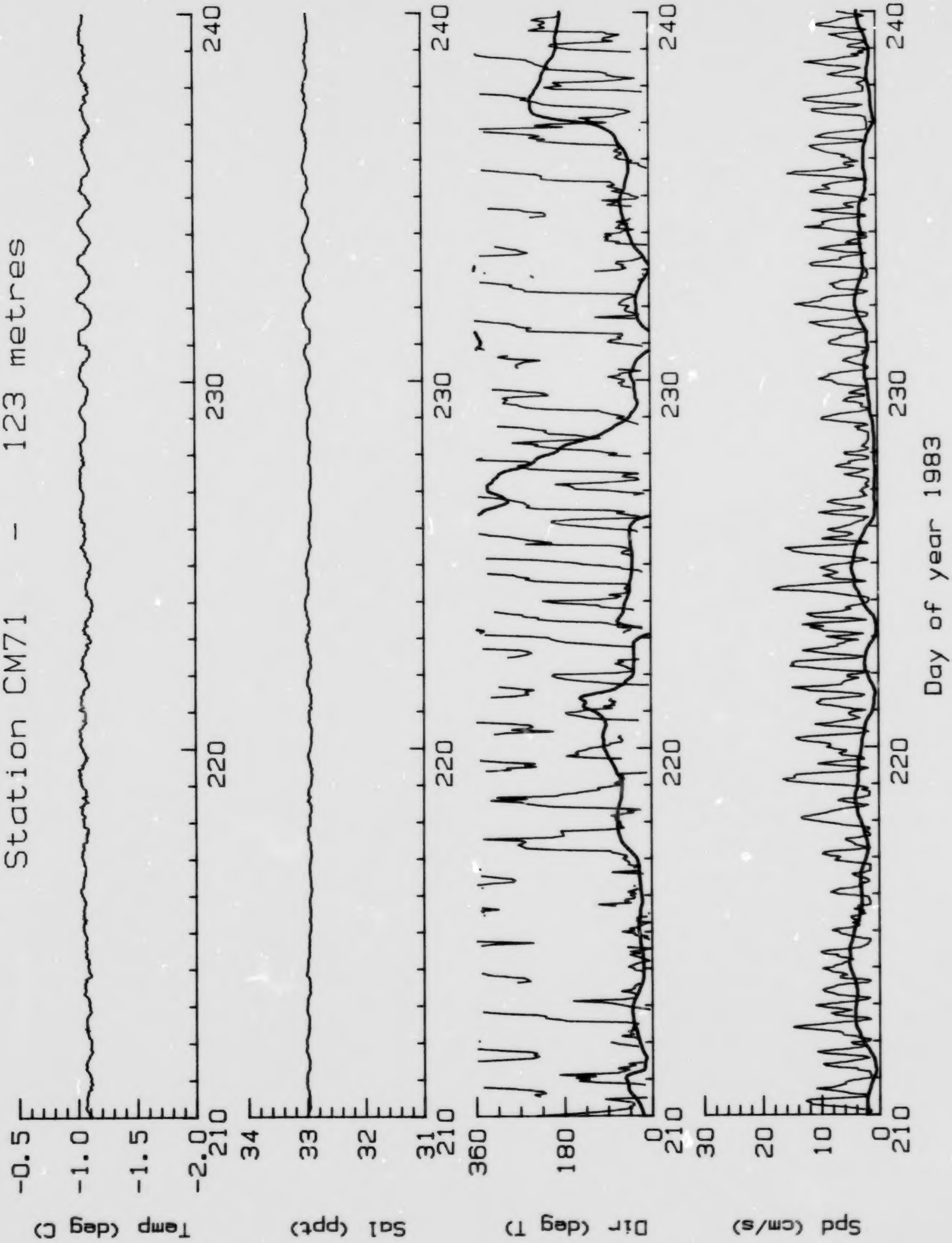

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1983

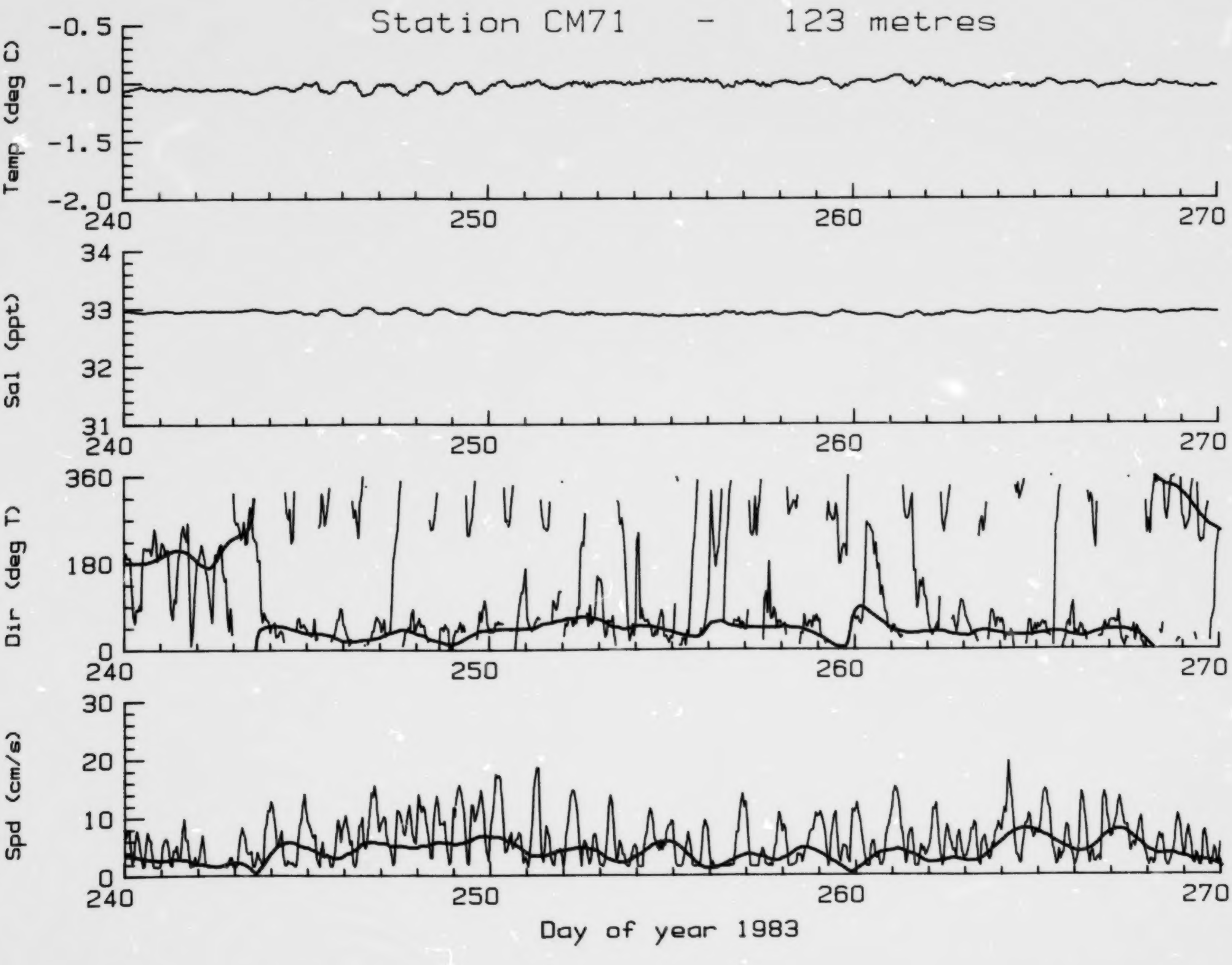

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1983

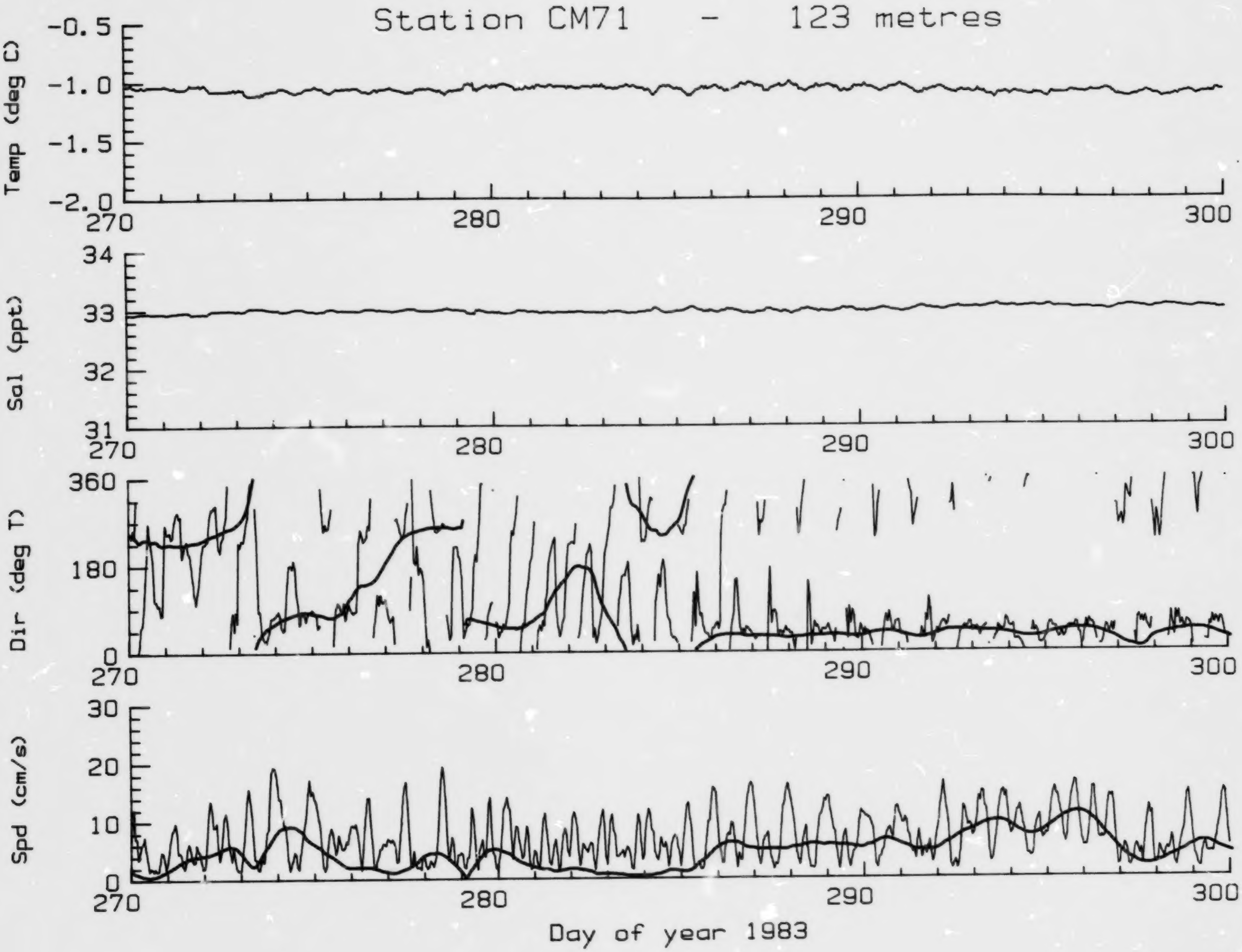

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1983

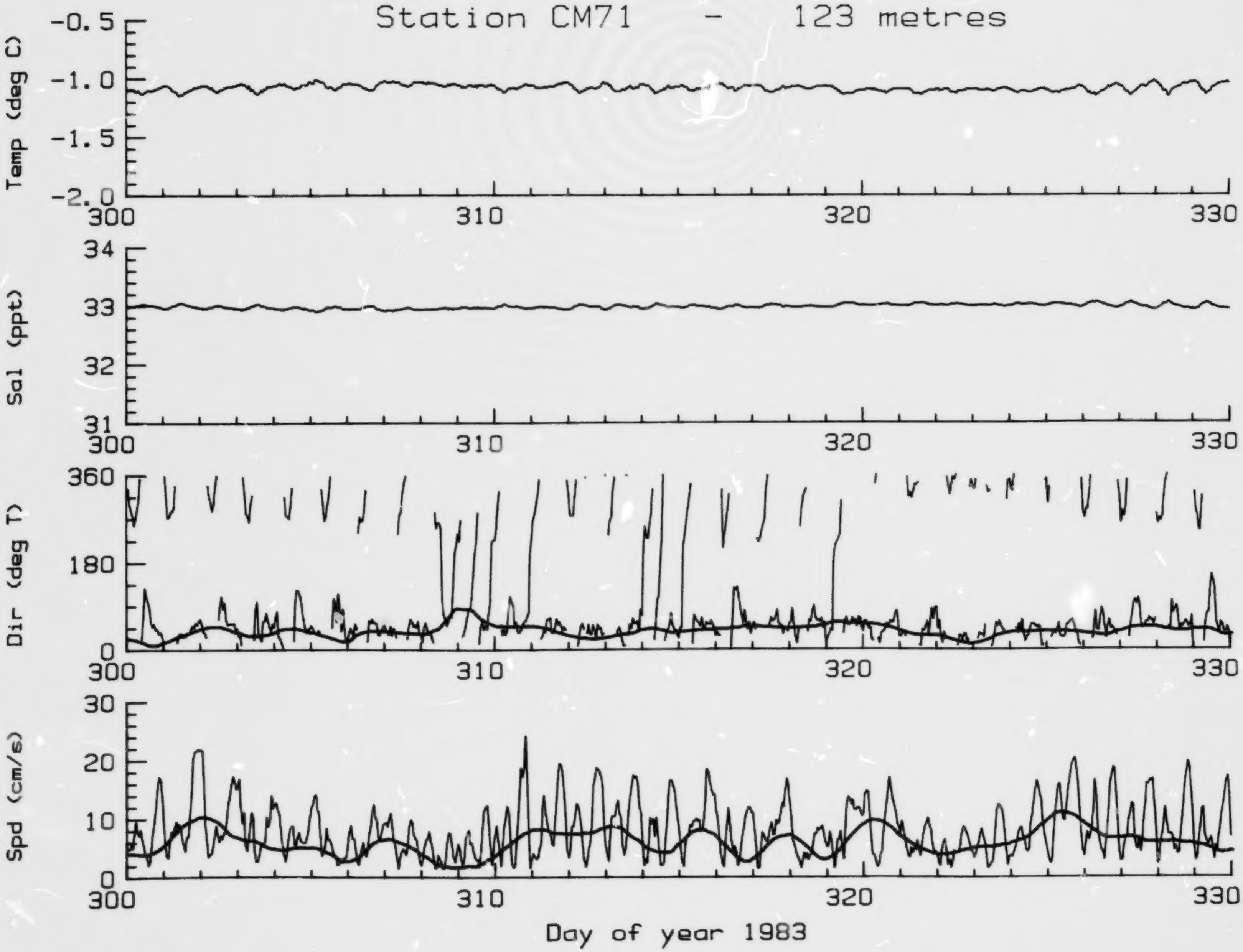


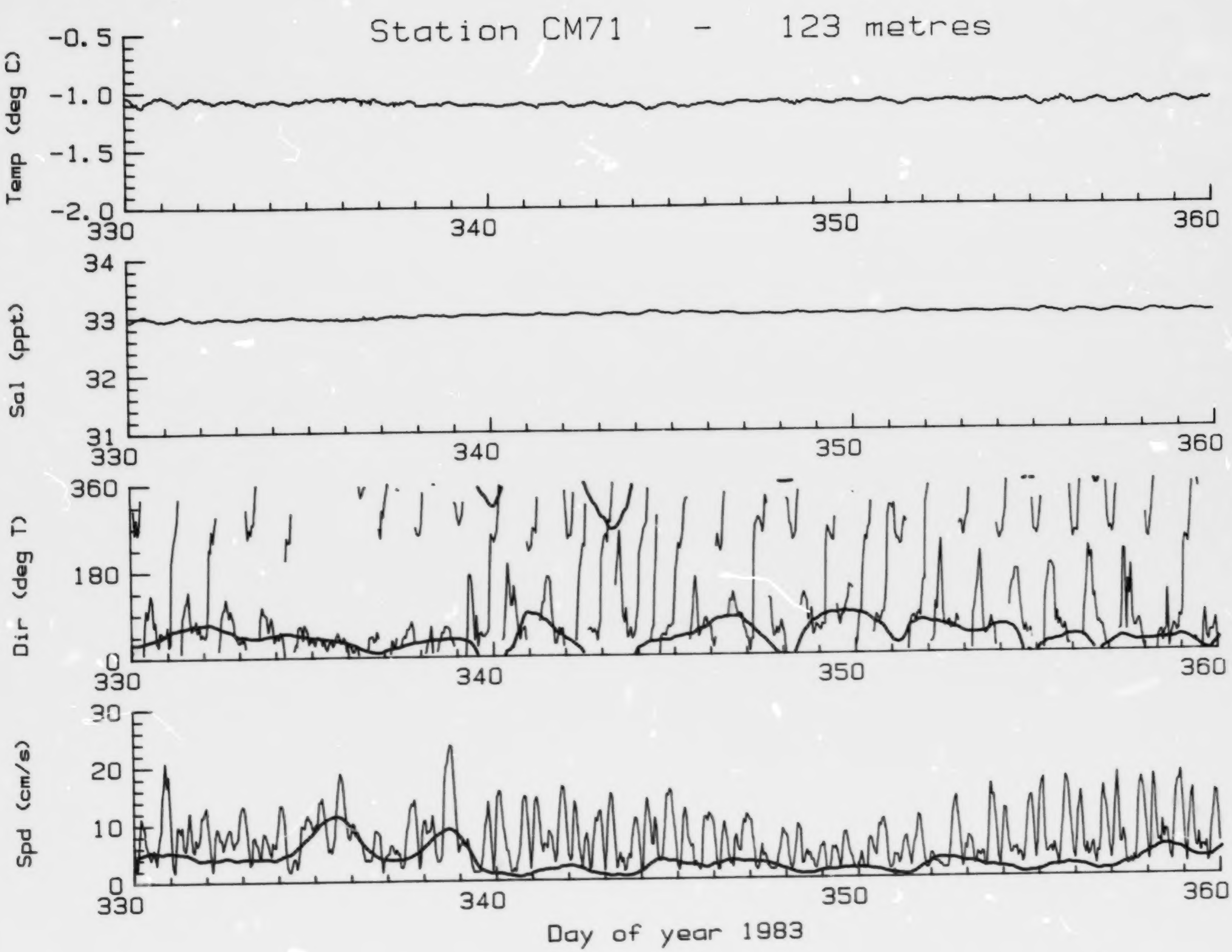
Station CM71 - 123 metres

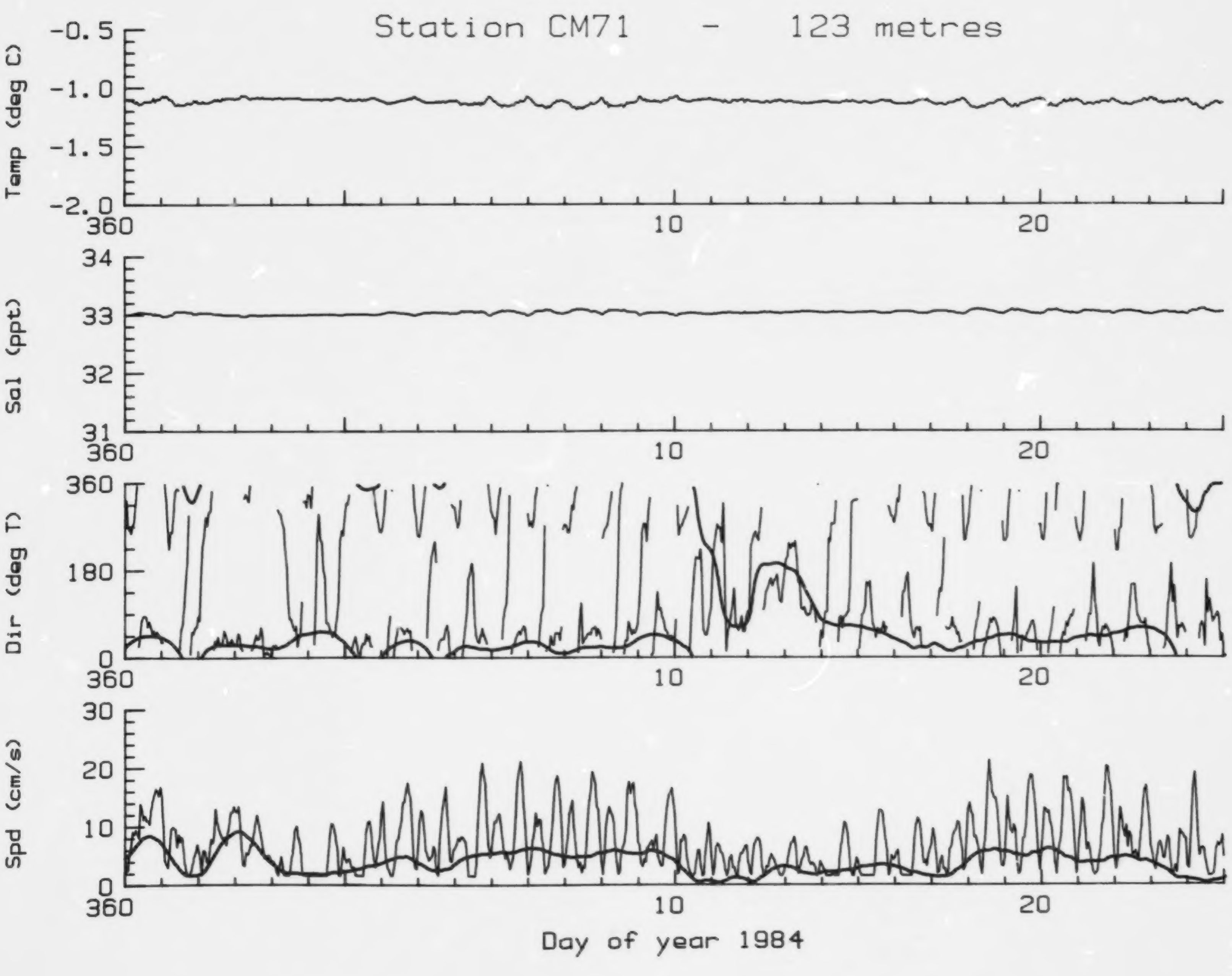

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
210
220
230
240
Day of year 1983

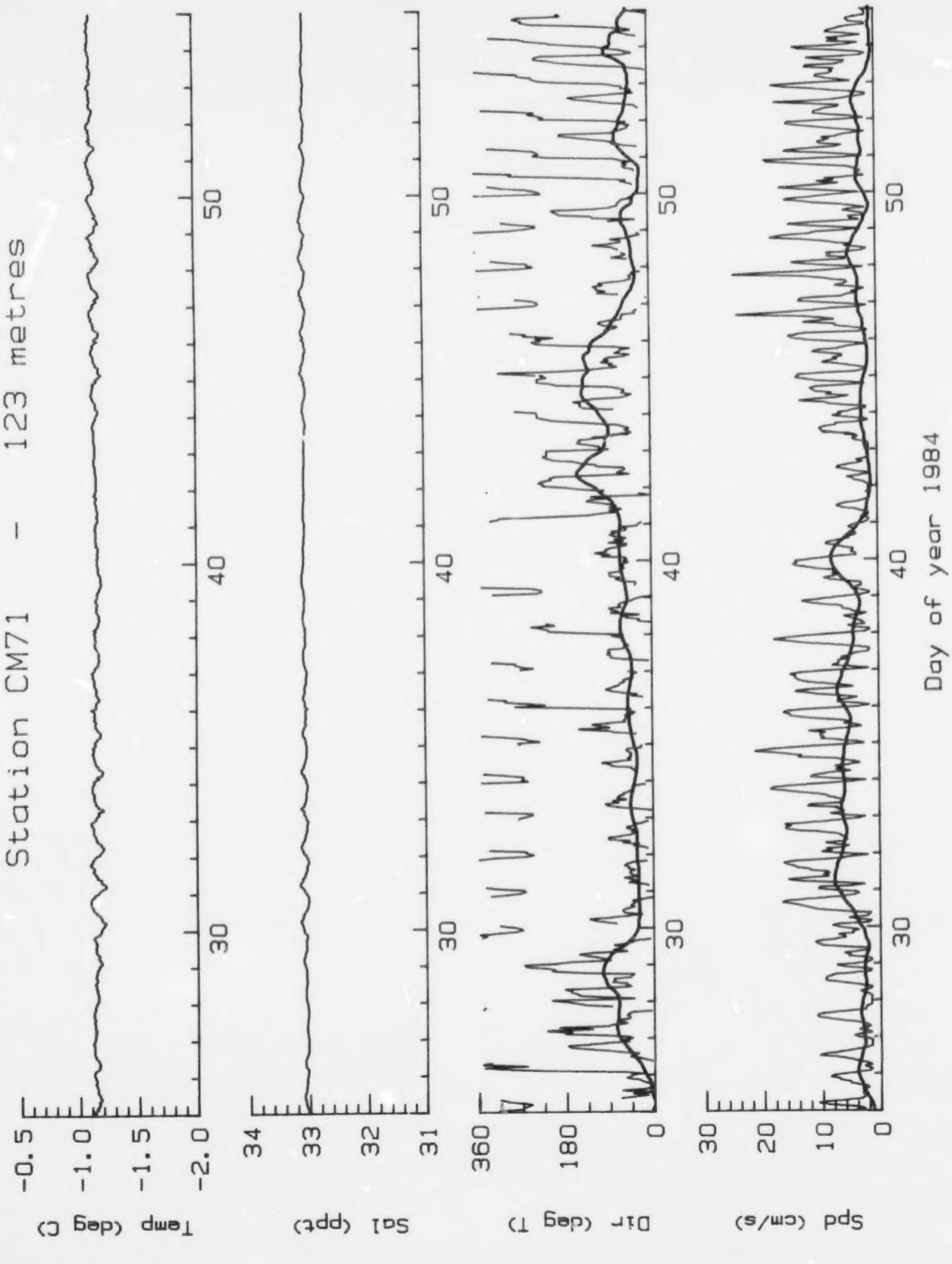

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
240
250
260
270
Day of year 1983

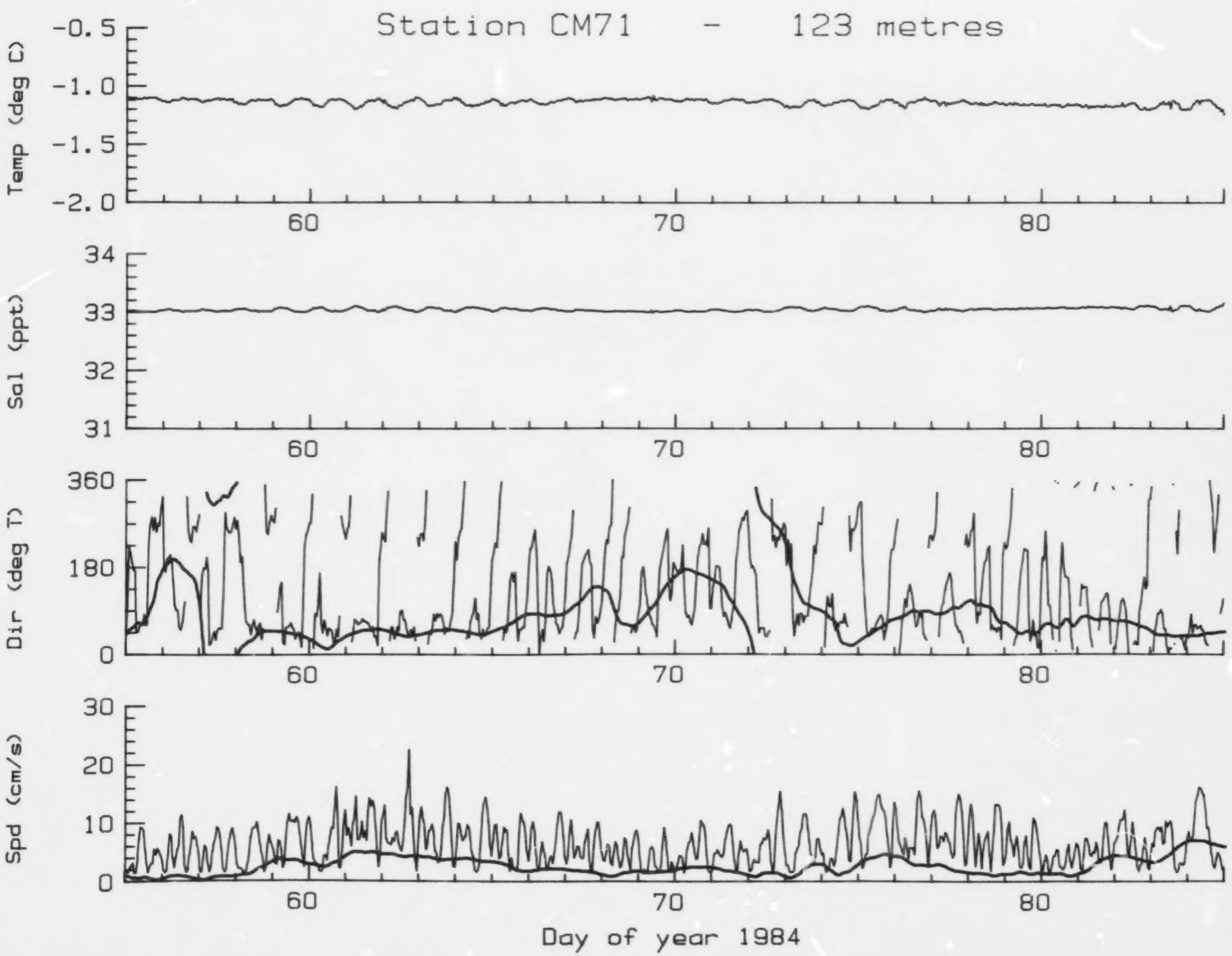

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
270
280
290
300
Sal (ppt)
34
33
32
31
270
280
290
300
Dir (deg T)
360
180
0
270
280
290
300
Spd (cm/s)
30
20
10
0
270
280
290
300
Day of year 1983

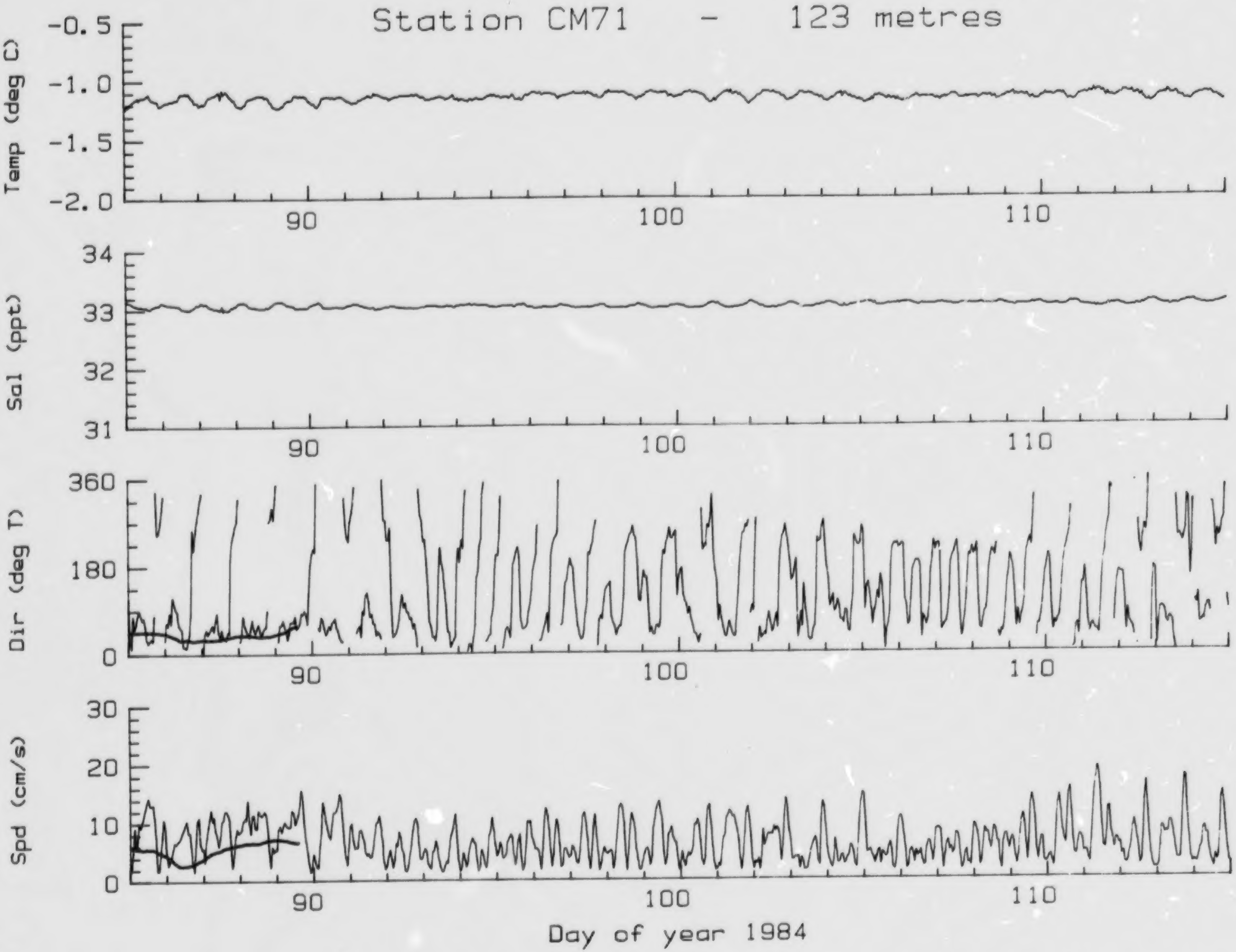

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
300
310
320
330
Day of year 1983

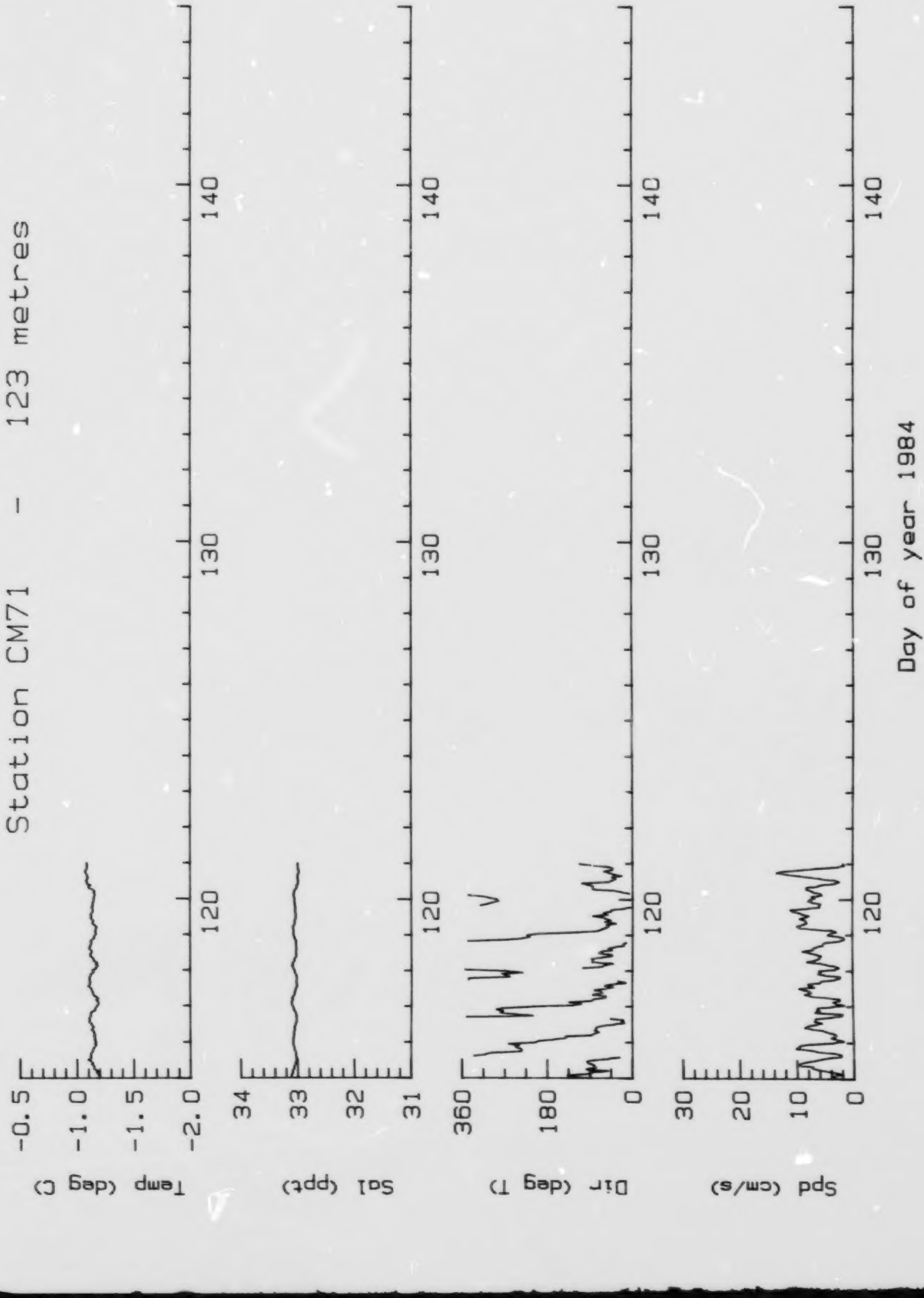

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
330
340
350
360
Day of year 1983

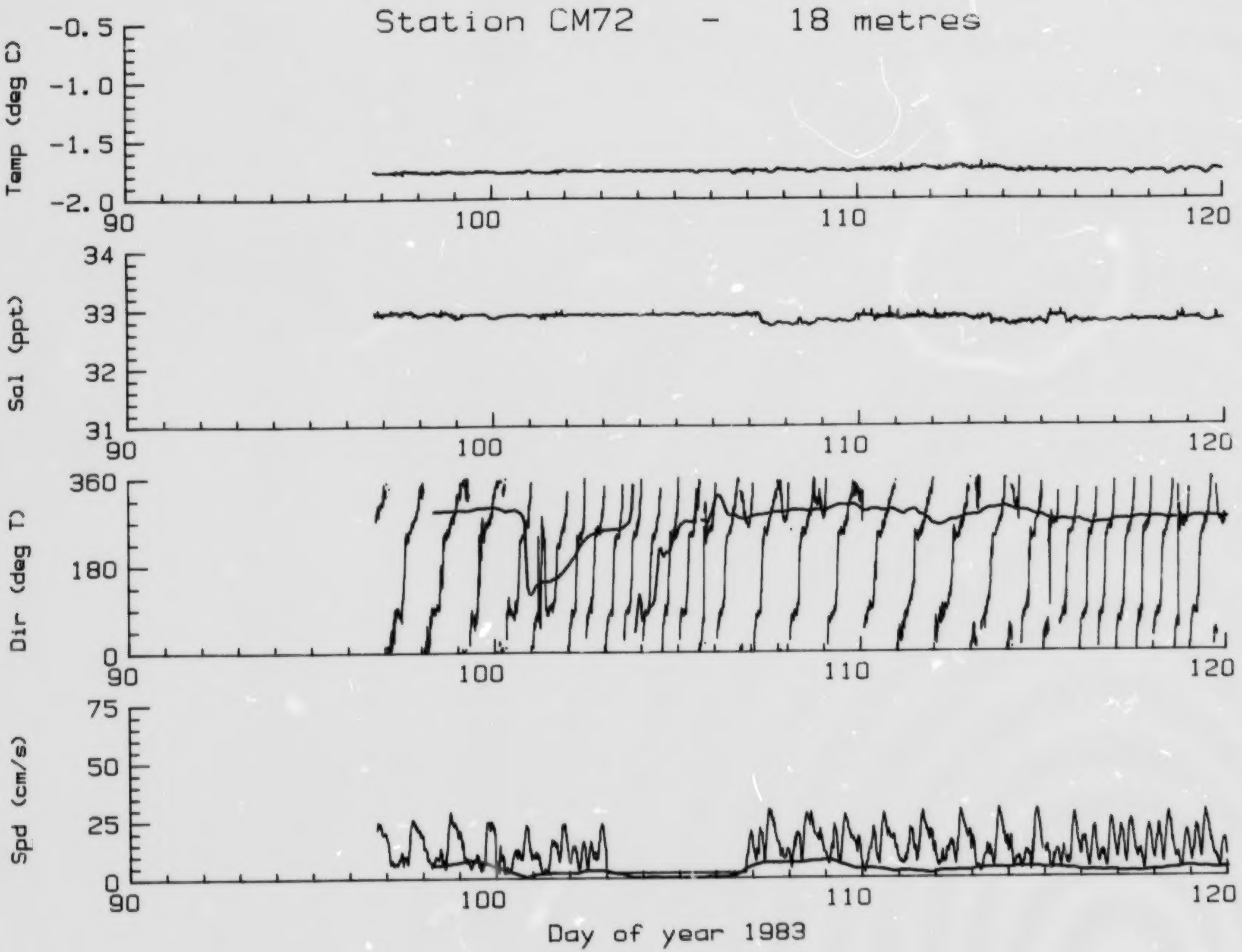

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
360
10
20
Day of year 1984

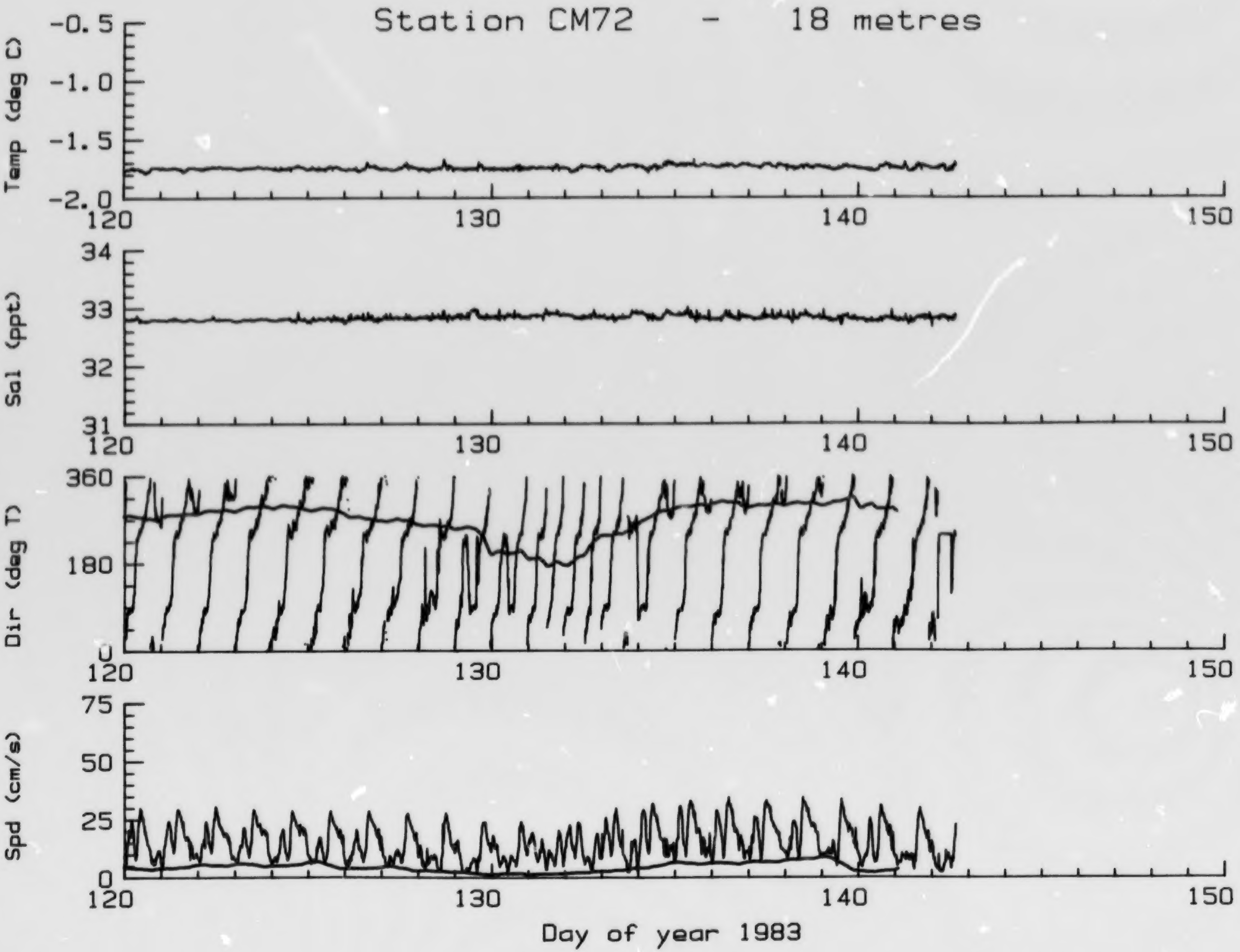

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
30
40
50
Day of year 1984


Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
60
70
80
Day of year 1984


Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
Day of year 1984

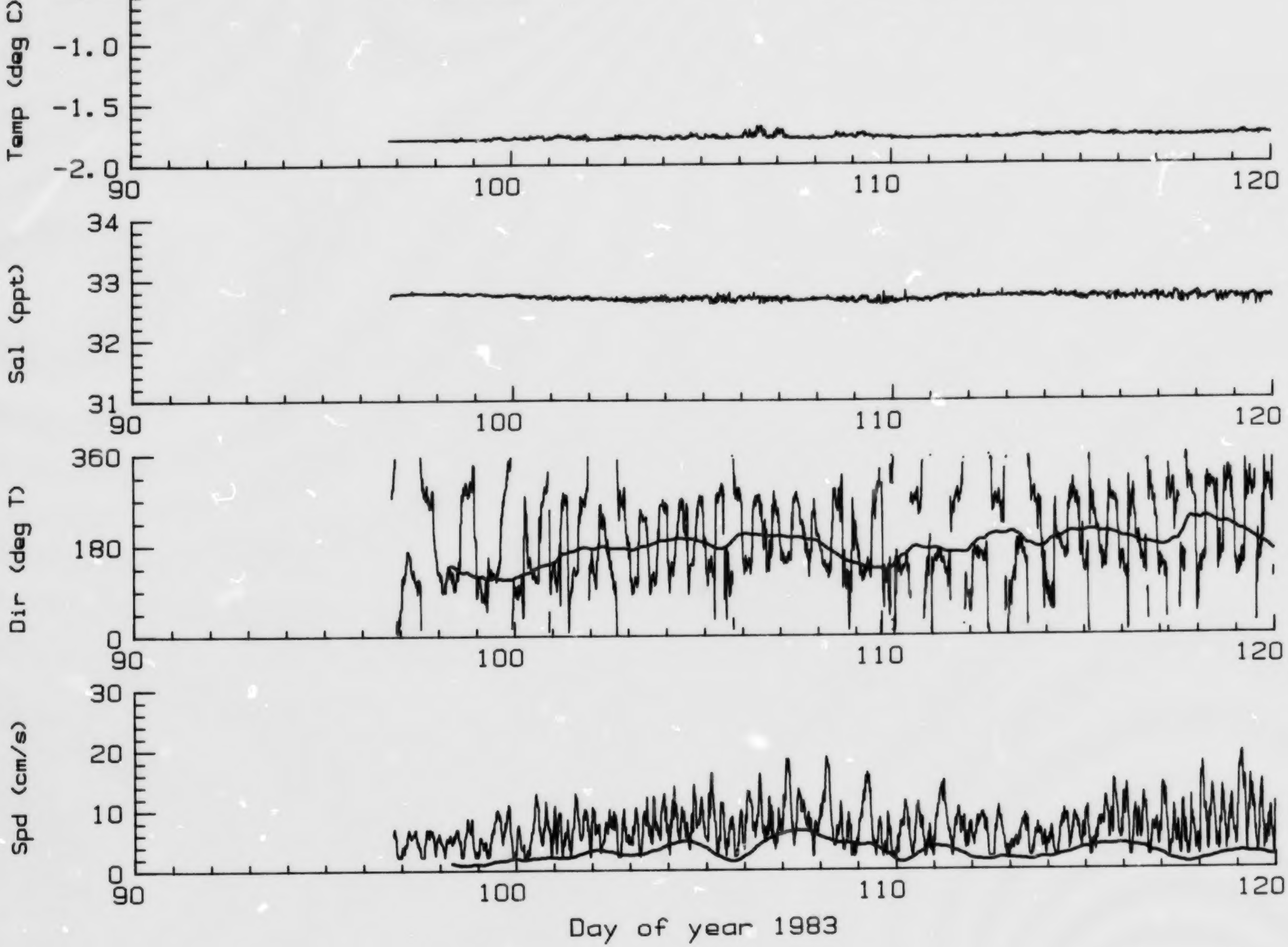

Station CM71 - 123 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
Day of year 1984

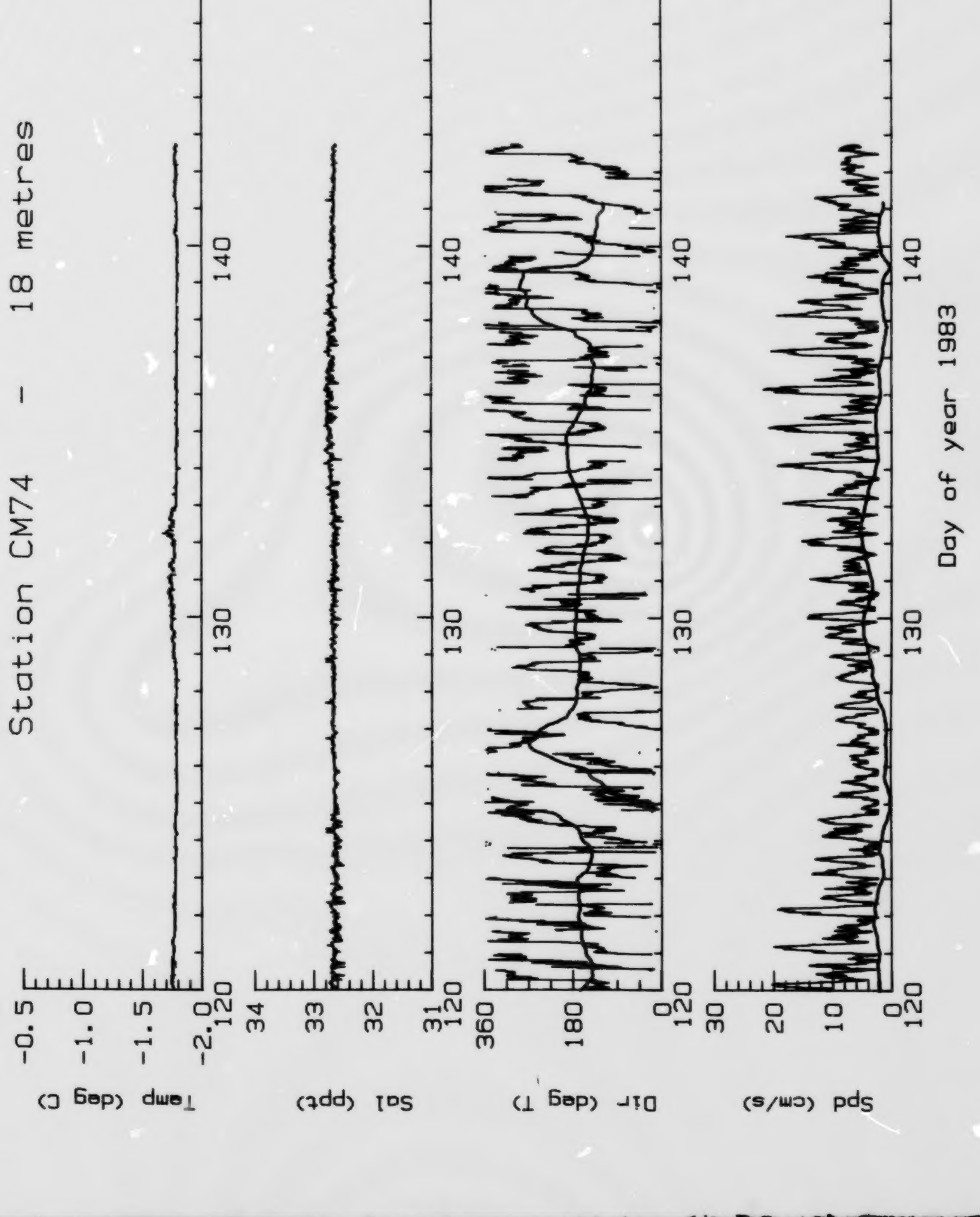

Station CM72 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1983

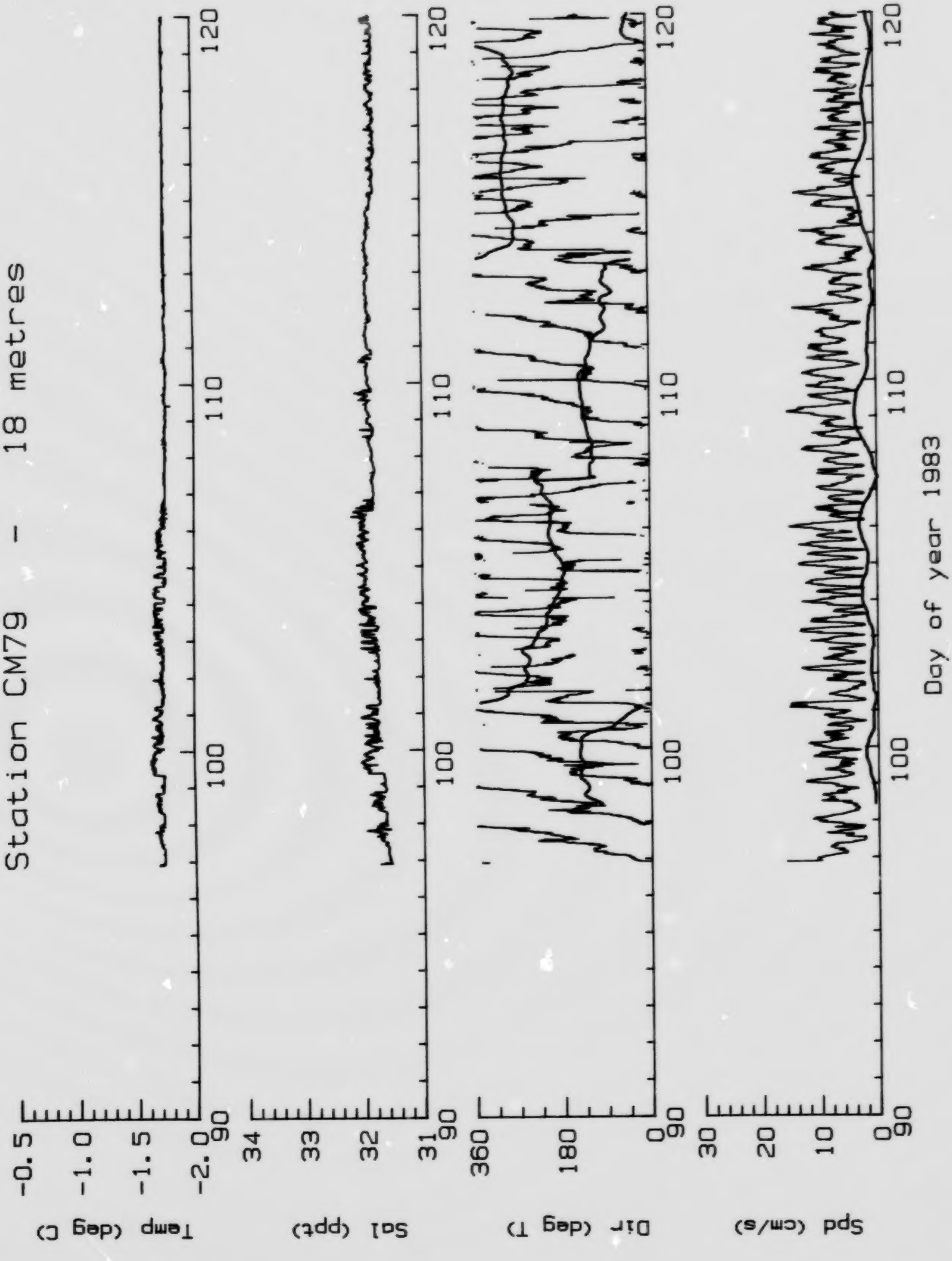


Station CM72 - 18 metres

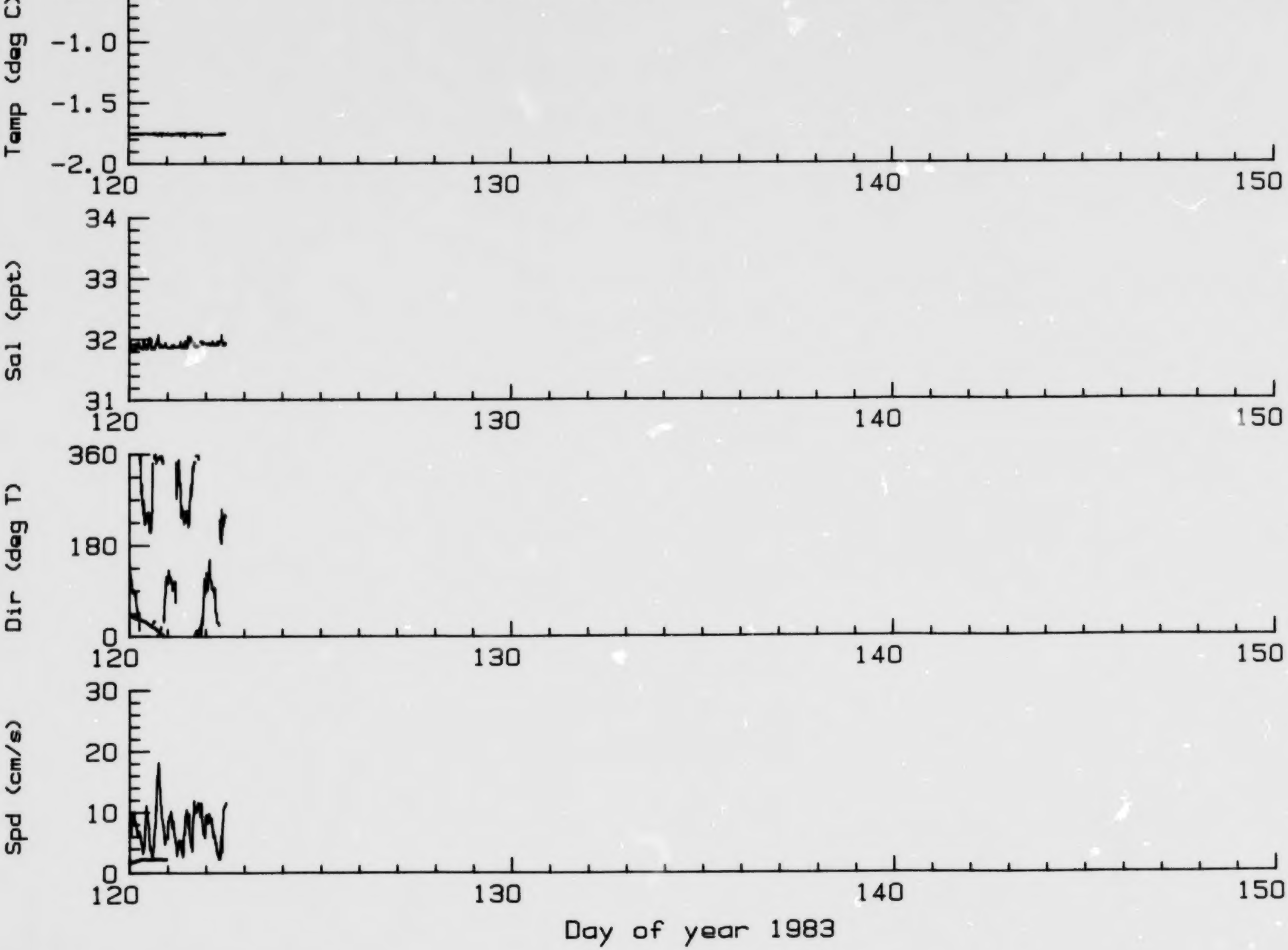
Station CM74 - 18 metres

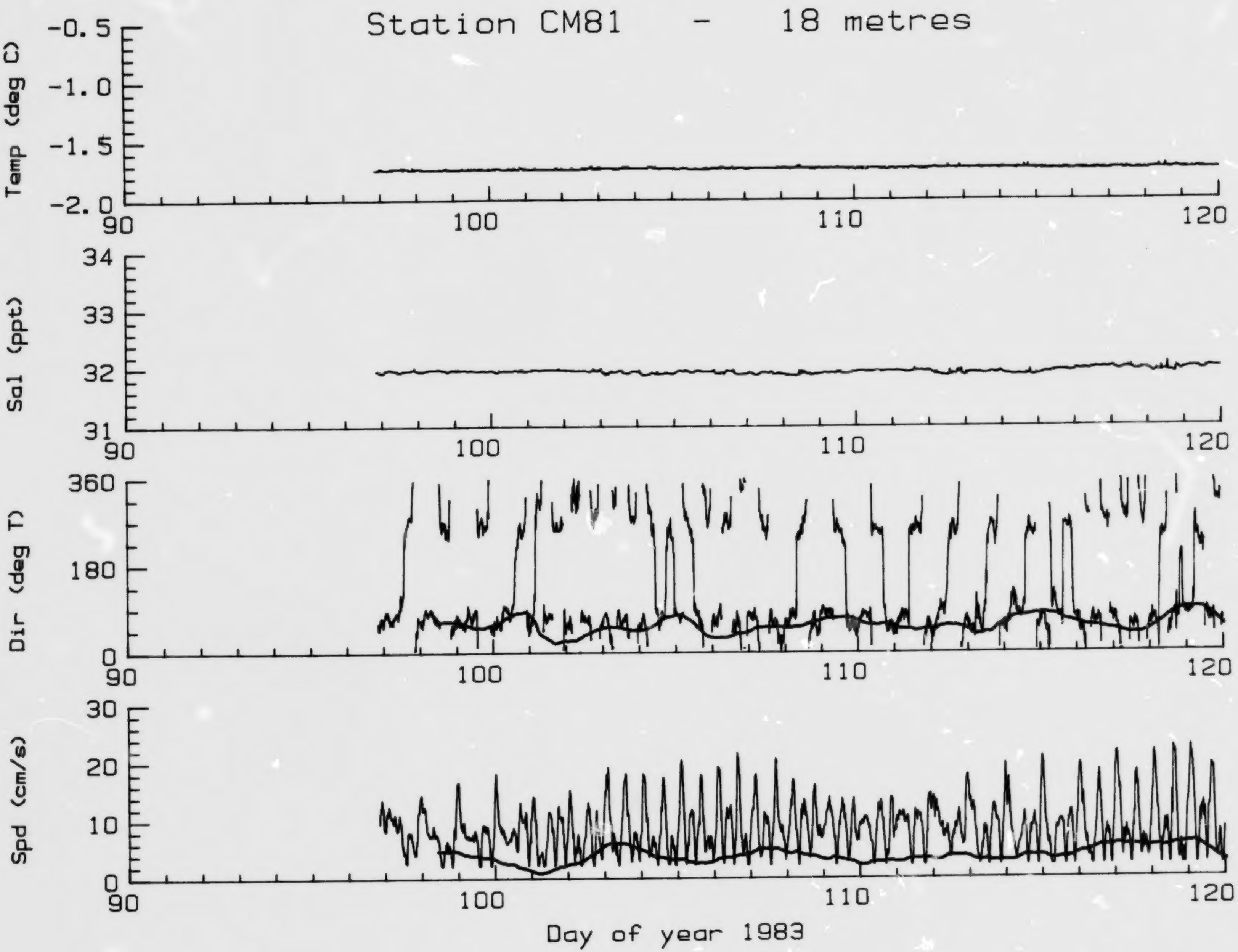


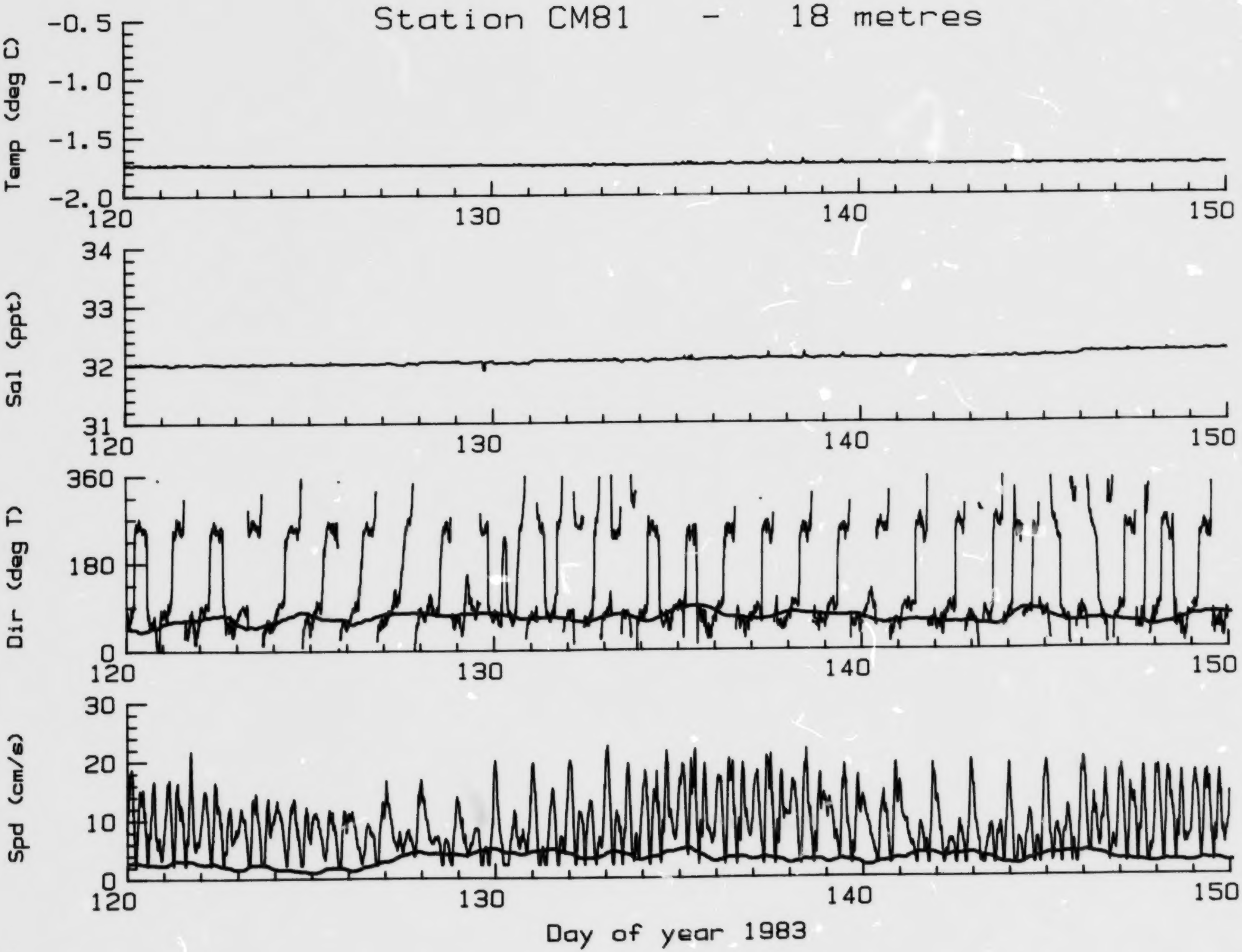

Station CM74 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1983

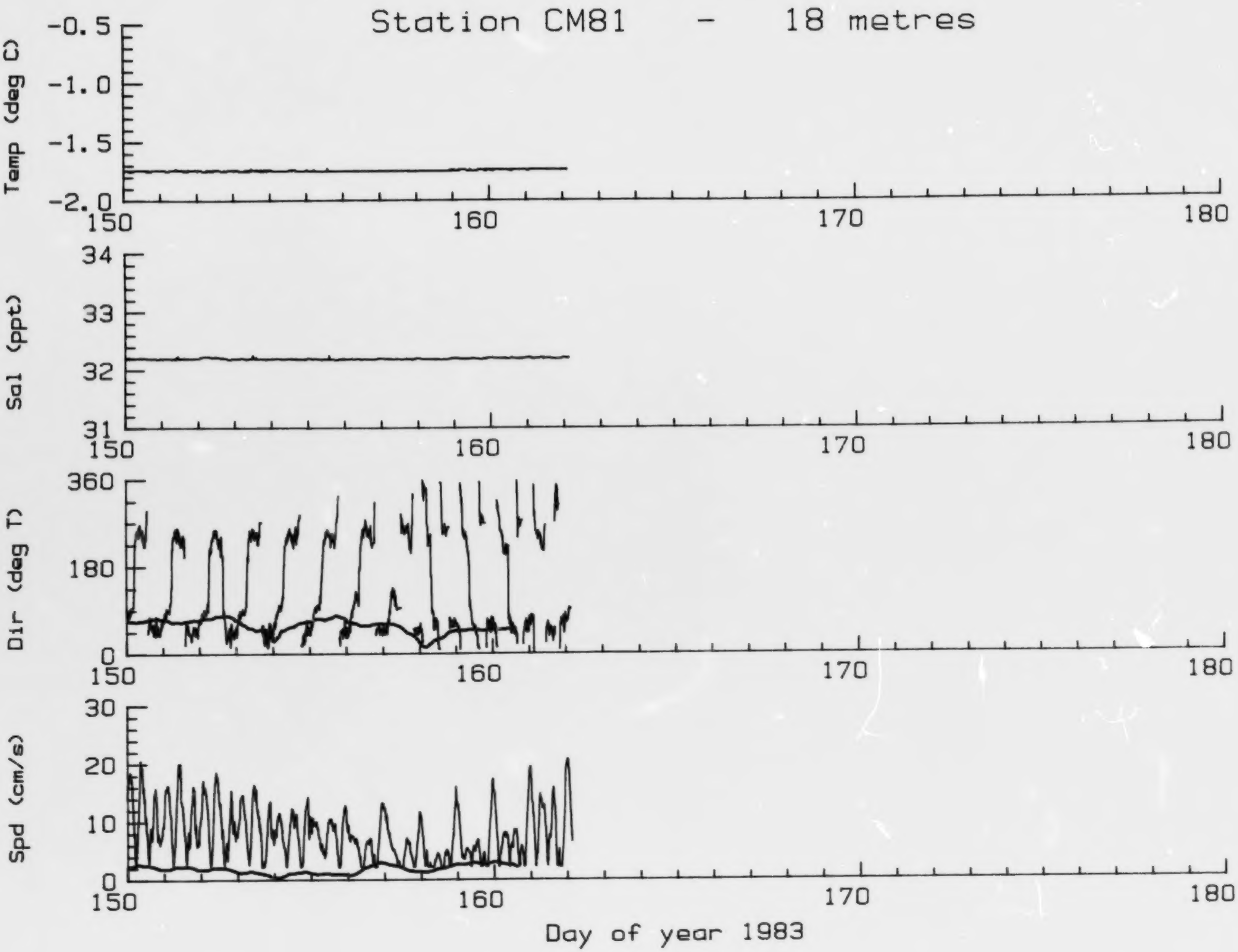

Station CM79 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1983

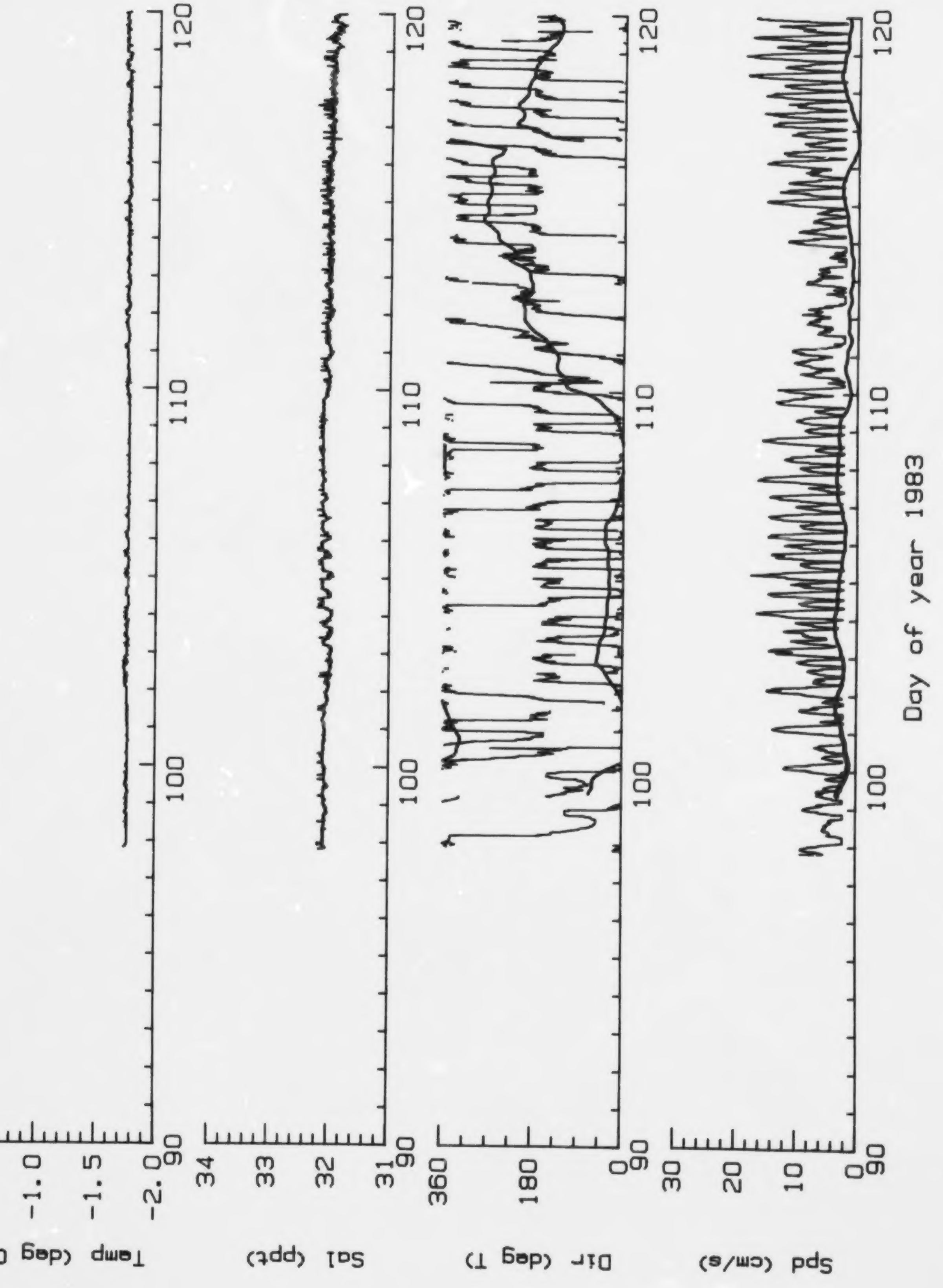
Station CM79 - 18 metres



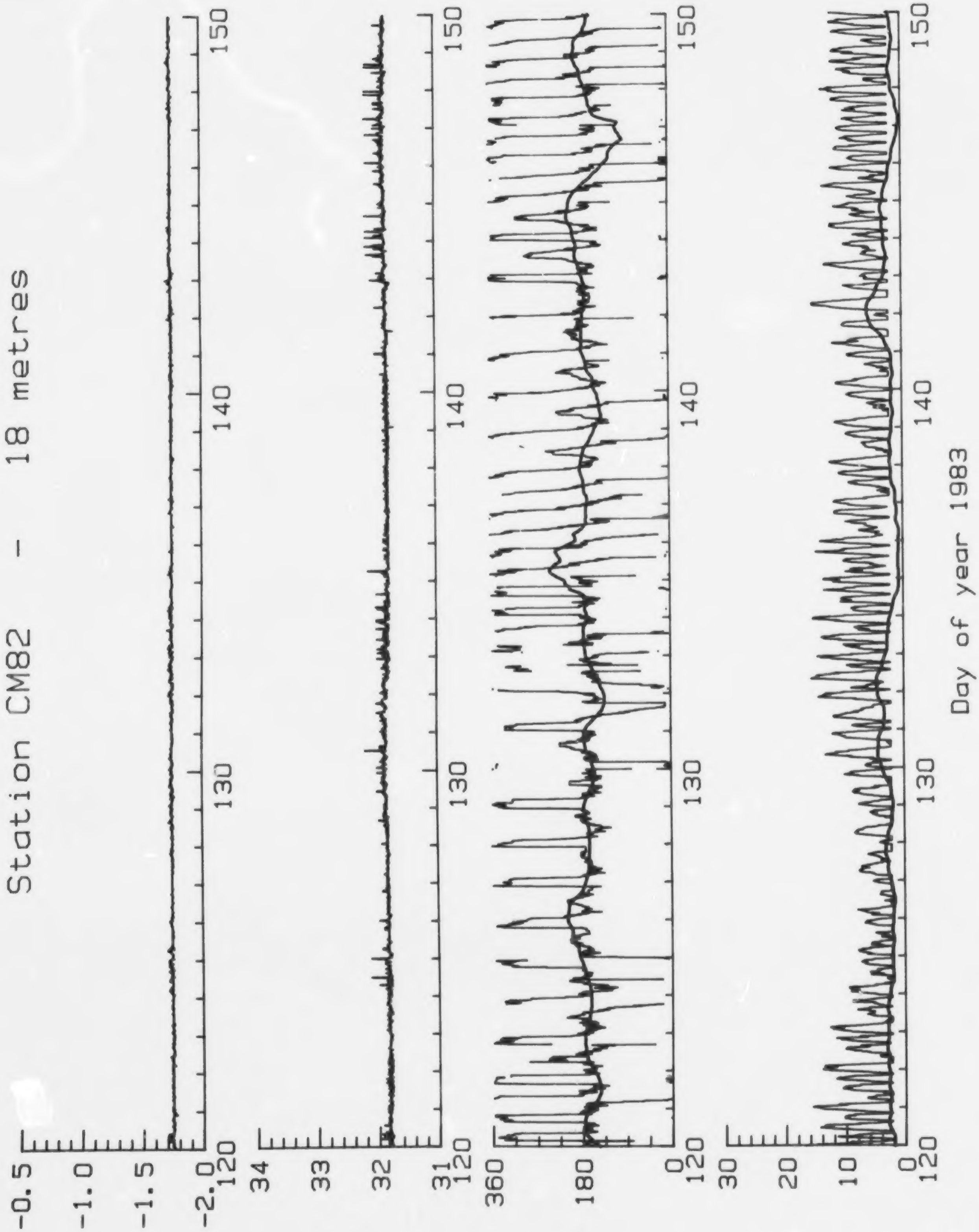

Station CM81 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1983

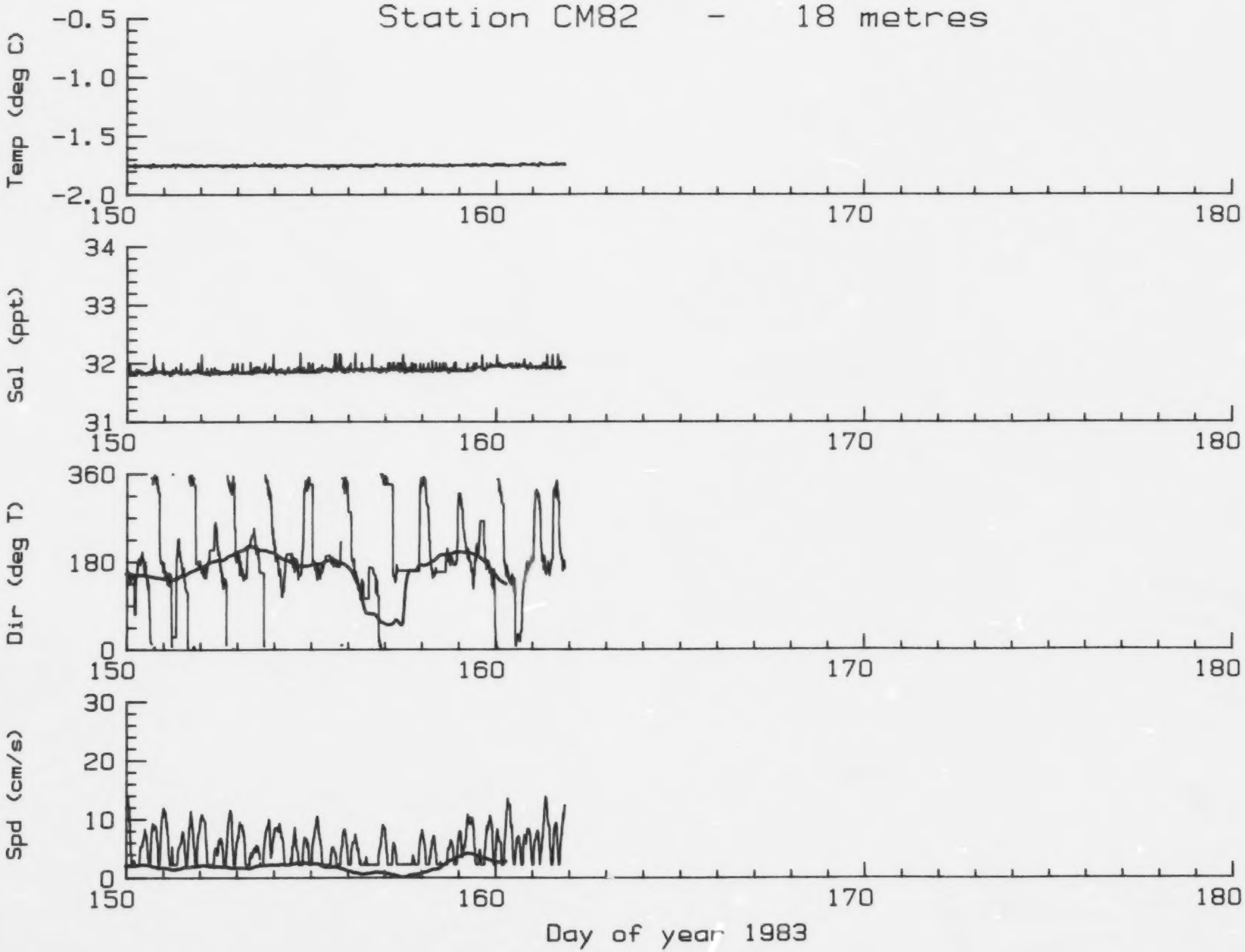

Station CM81 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1983

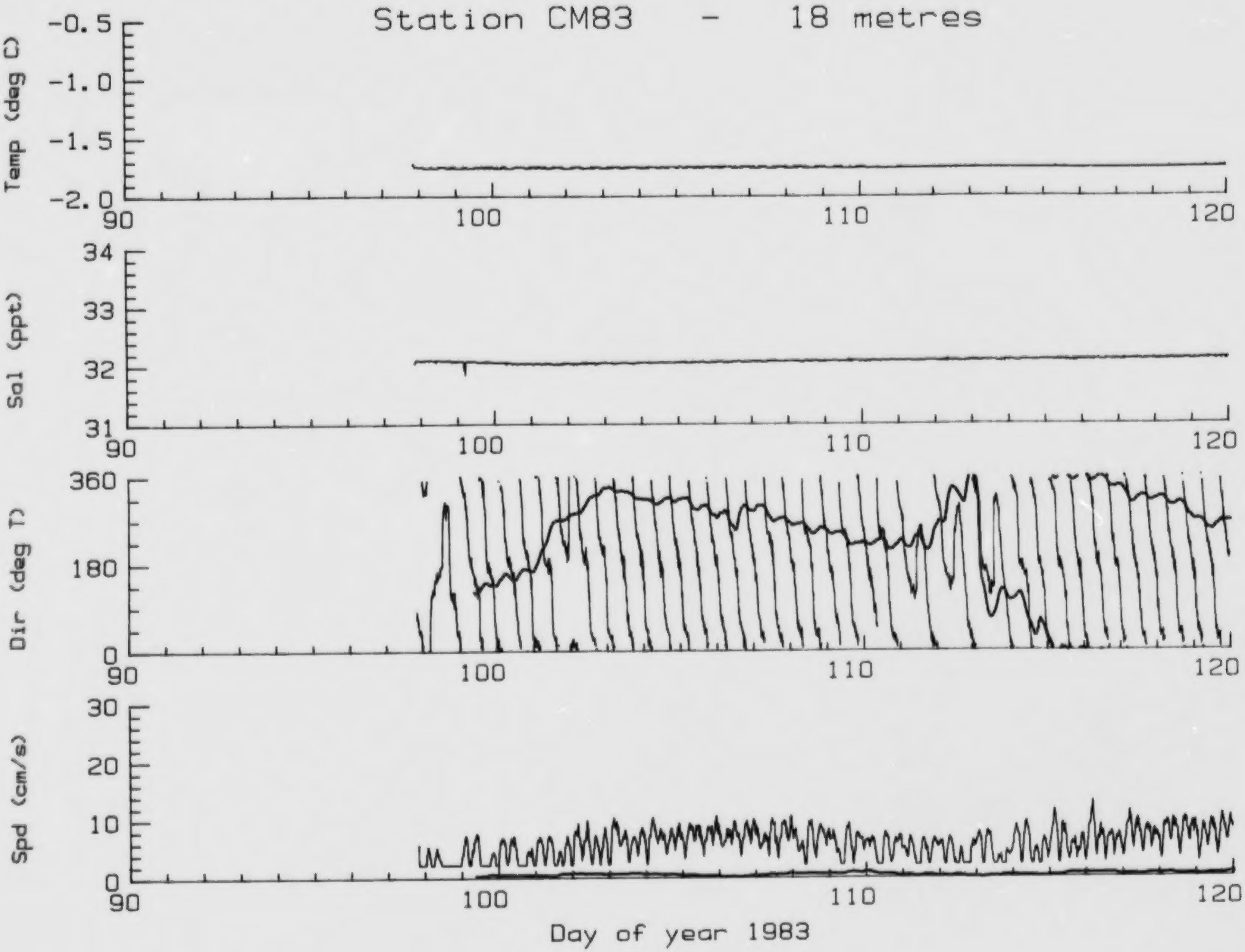

Station CM81 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1983



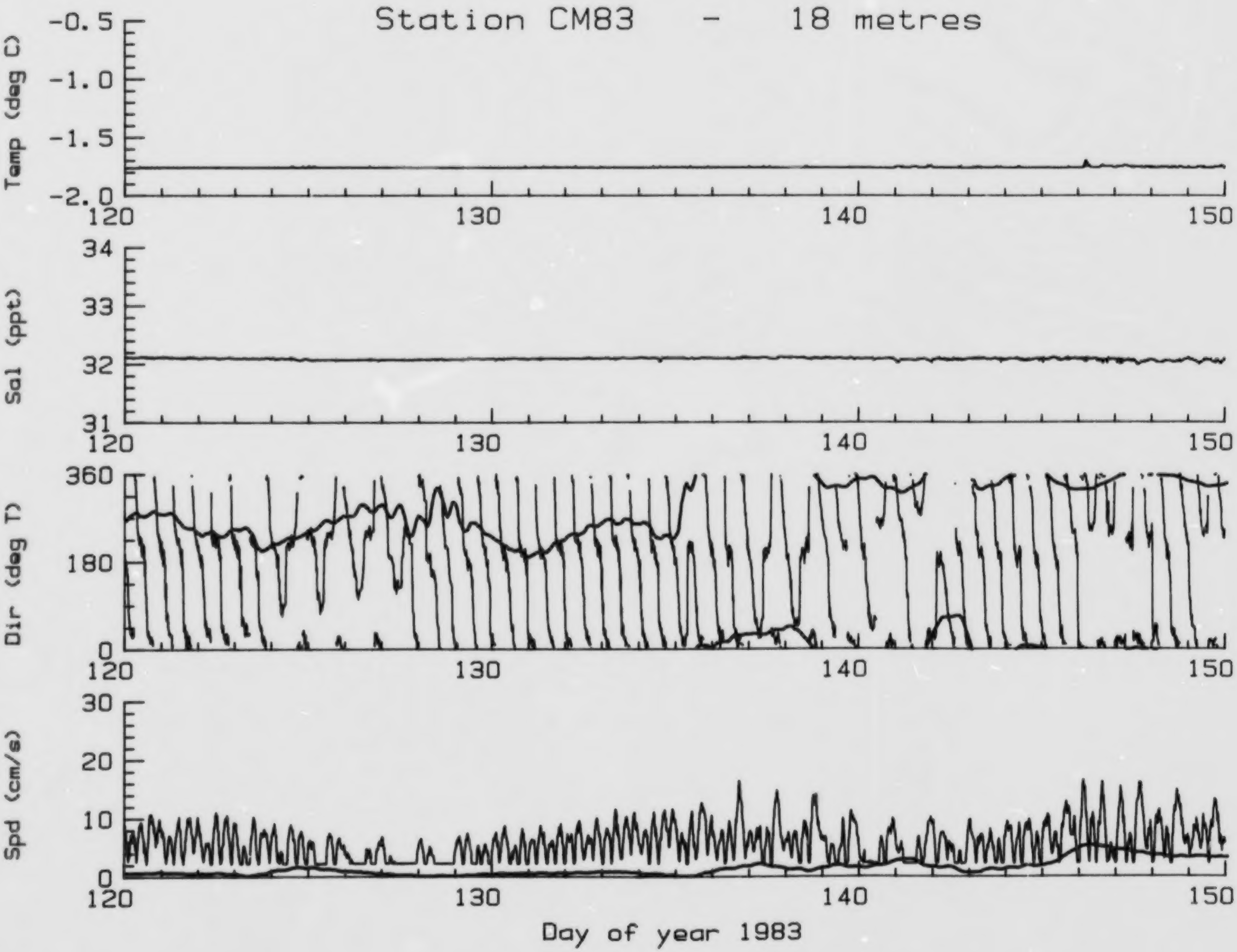
Station CM82 - 18 metres

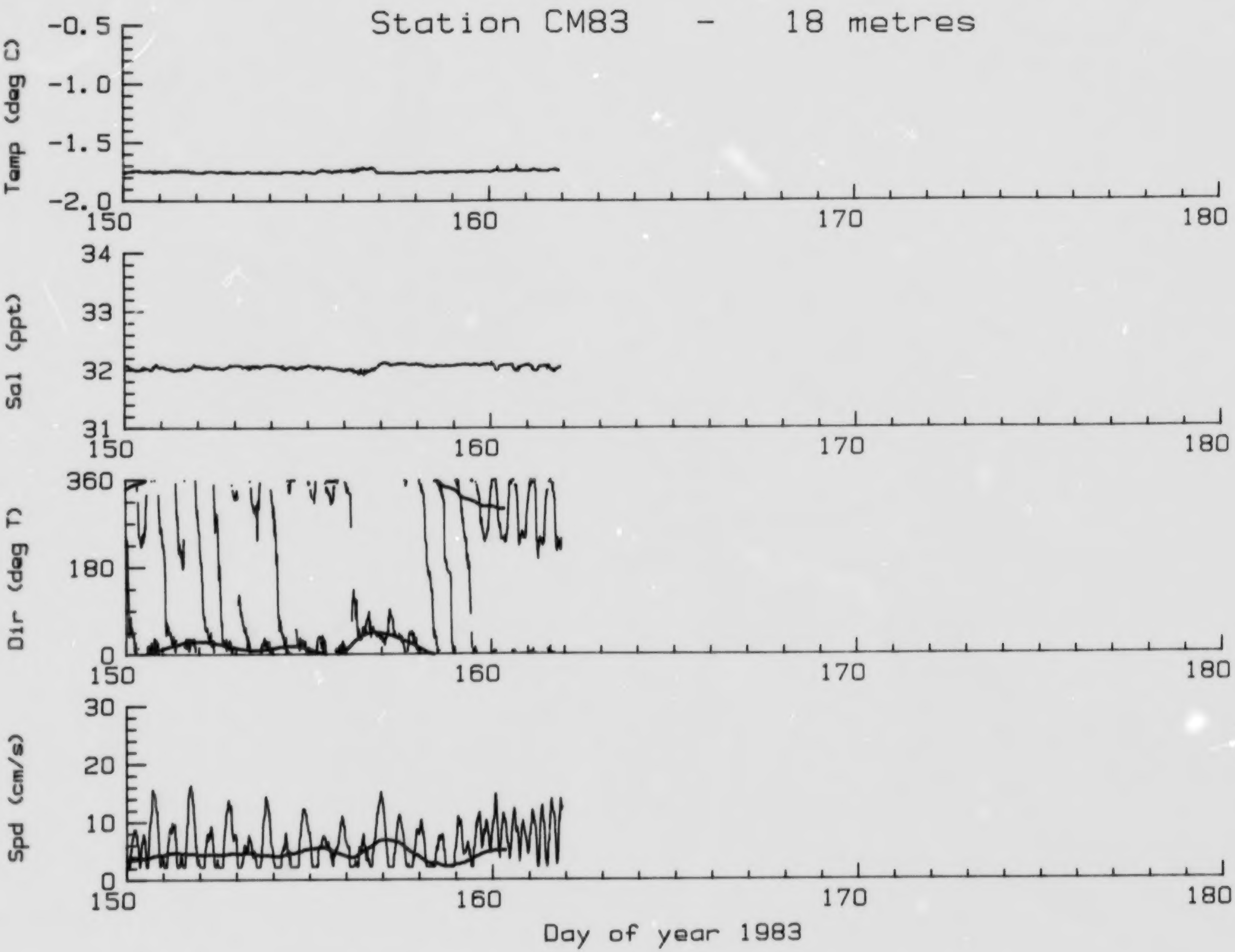

Station CM82 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1983

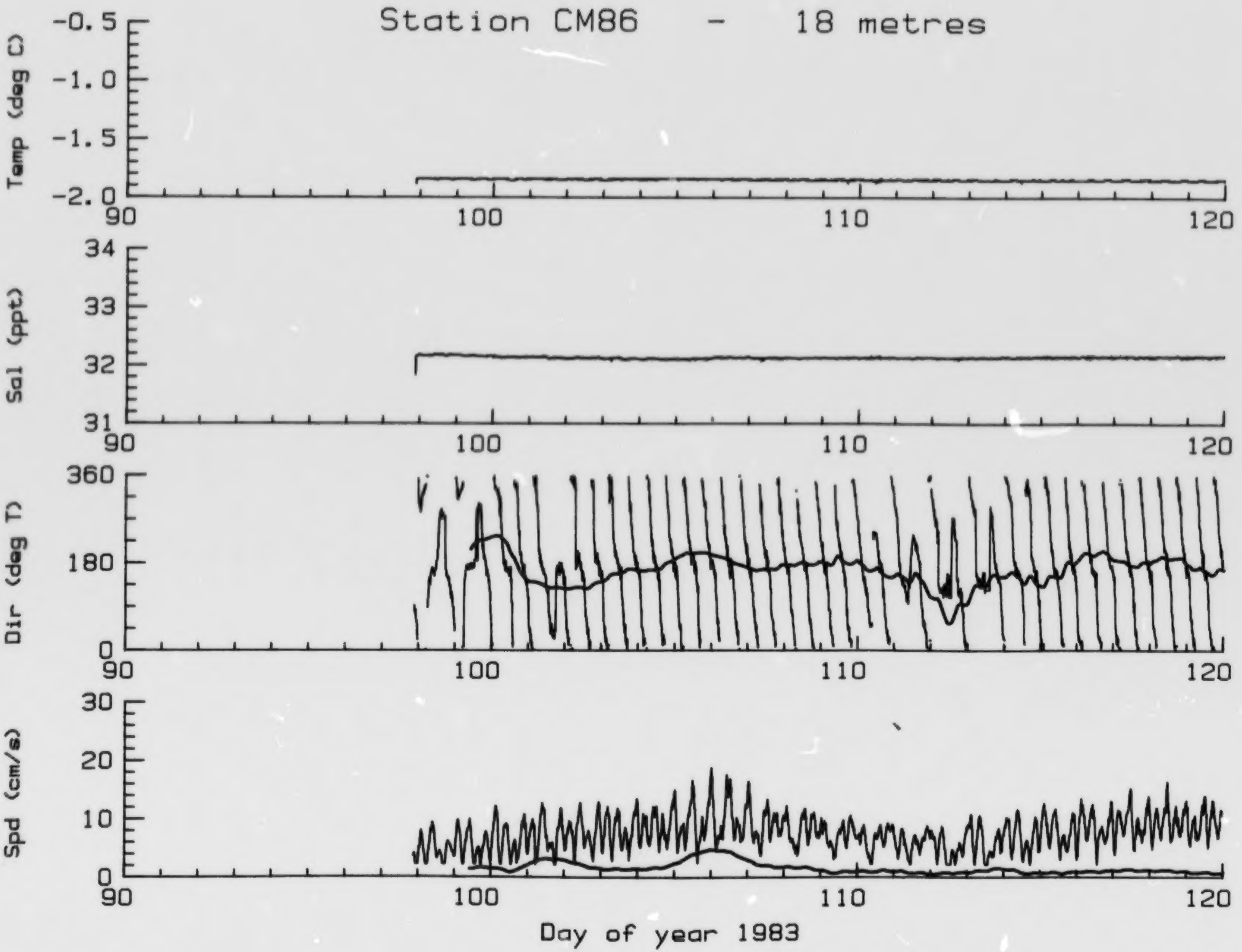

Station CM82 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1983

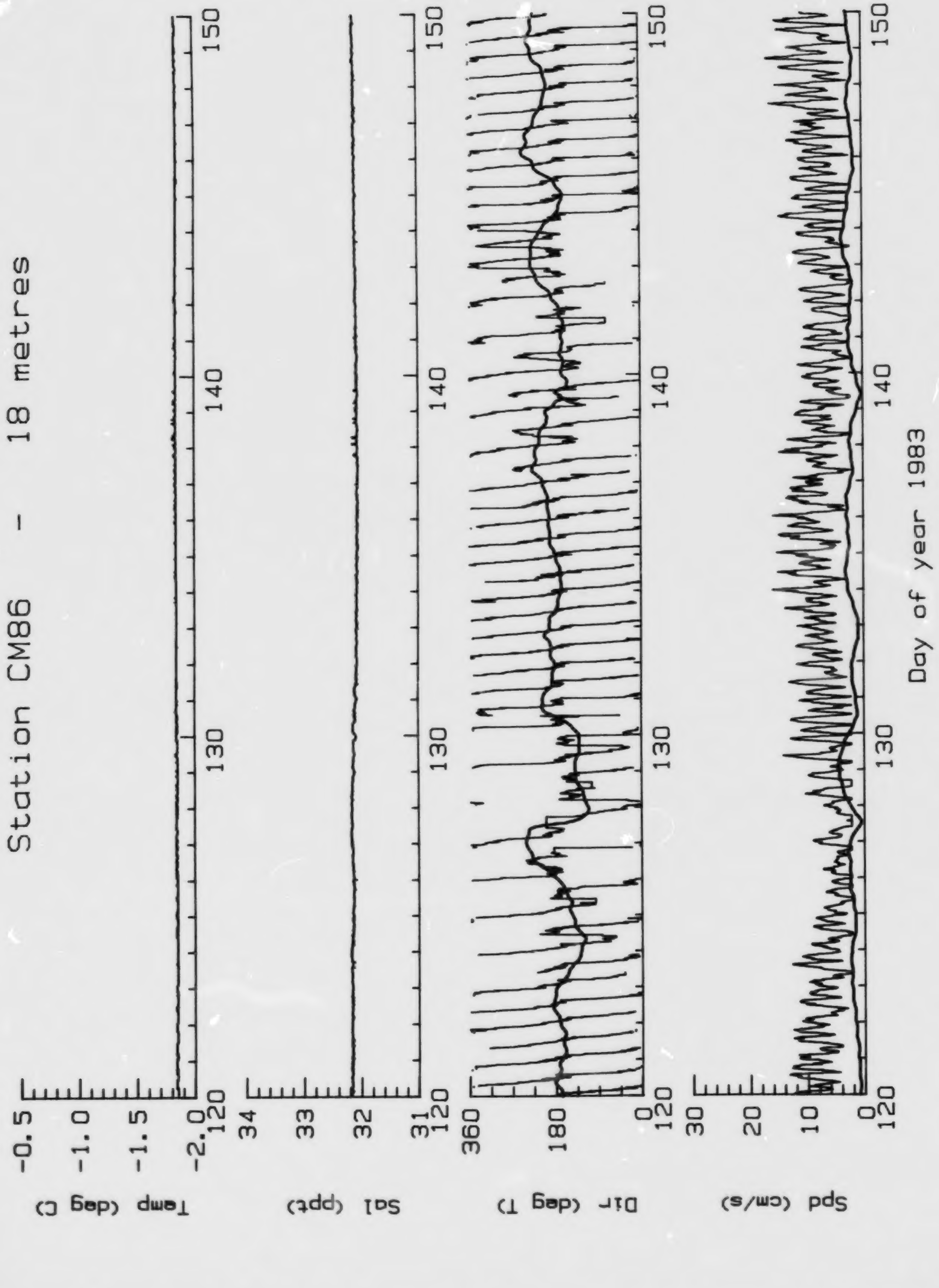


Station CM83 - 18 metres

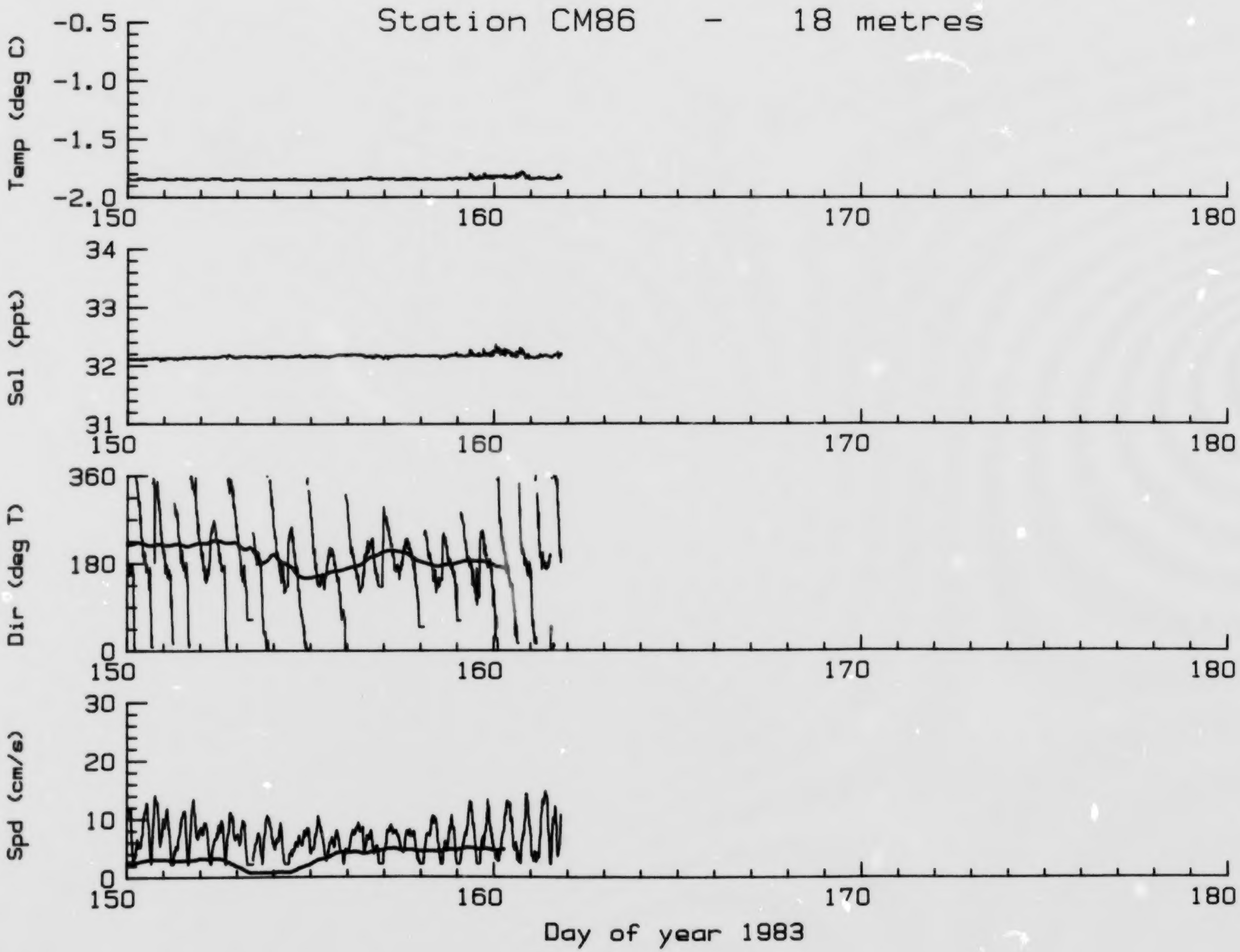

Station CM83 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1983

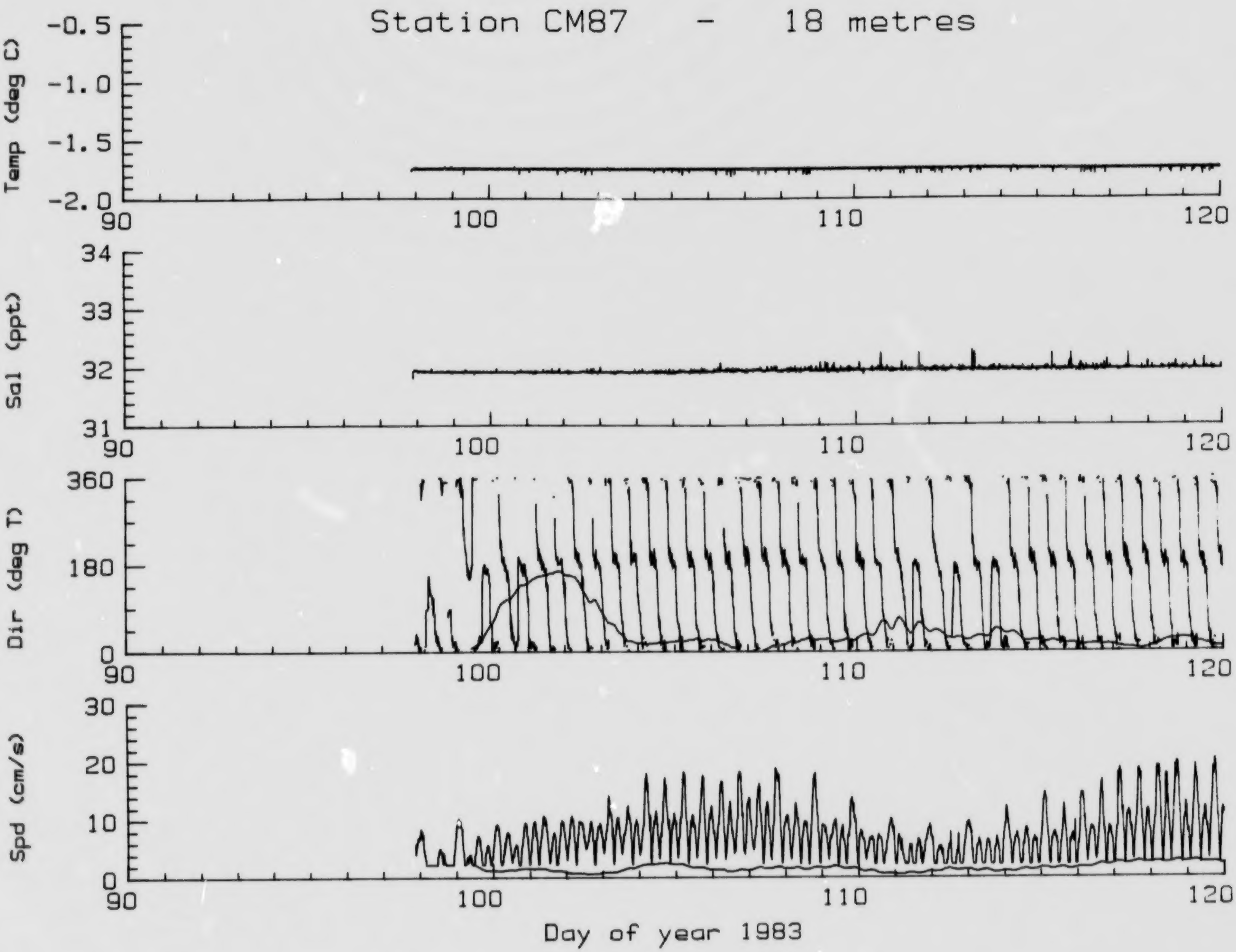

Station CM83 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1983

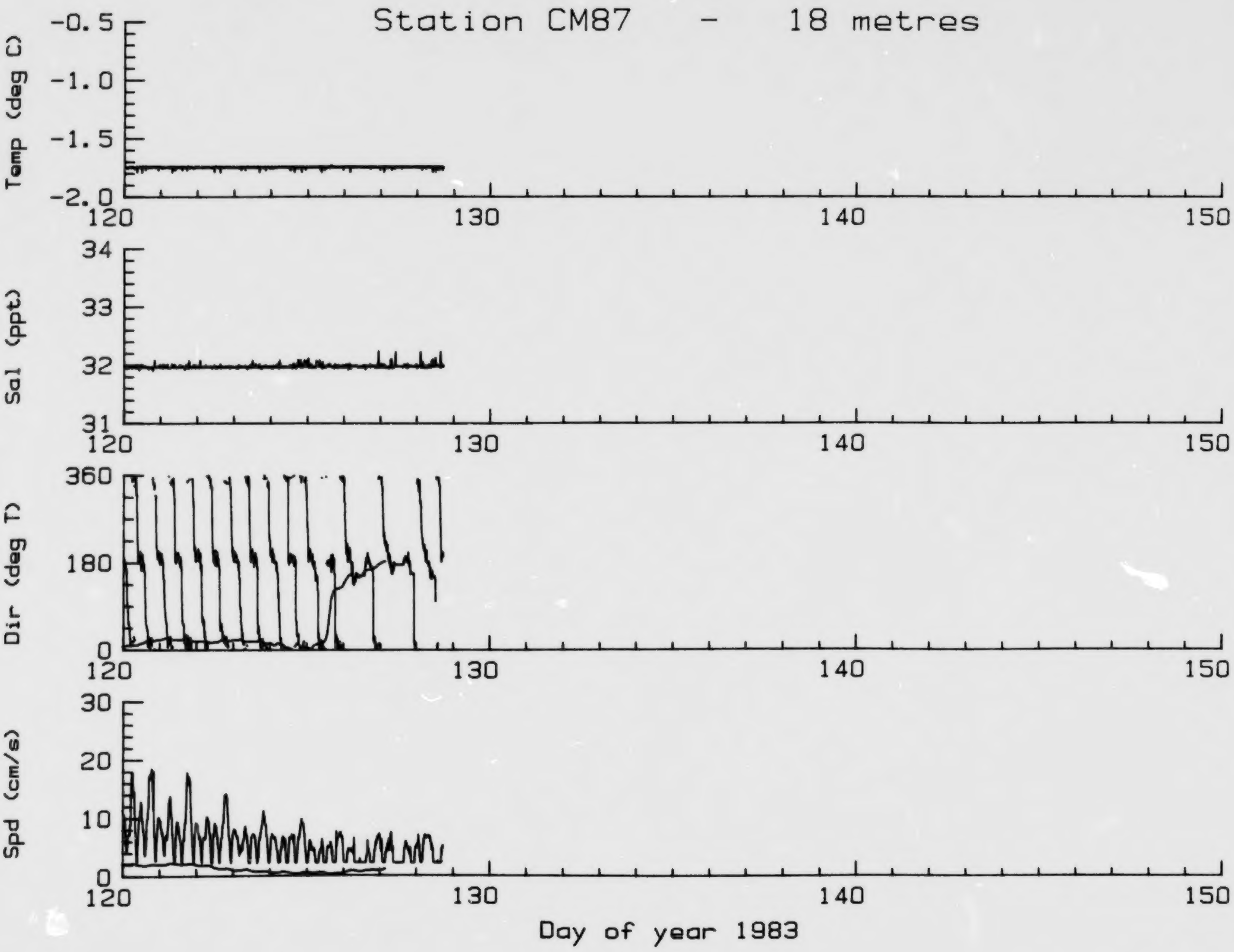

Station CM86 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1983

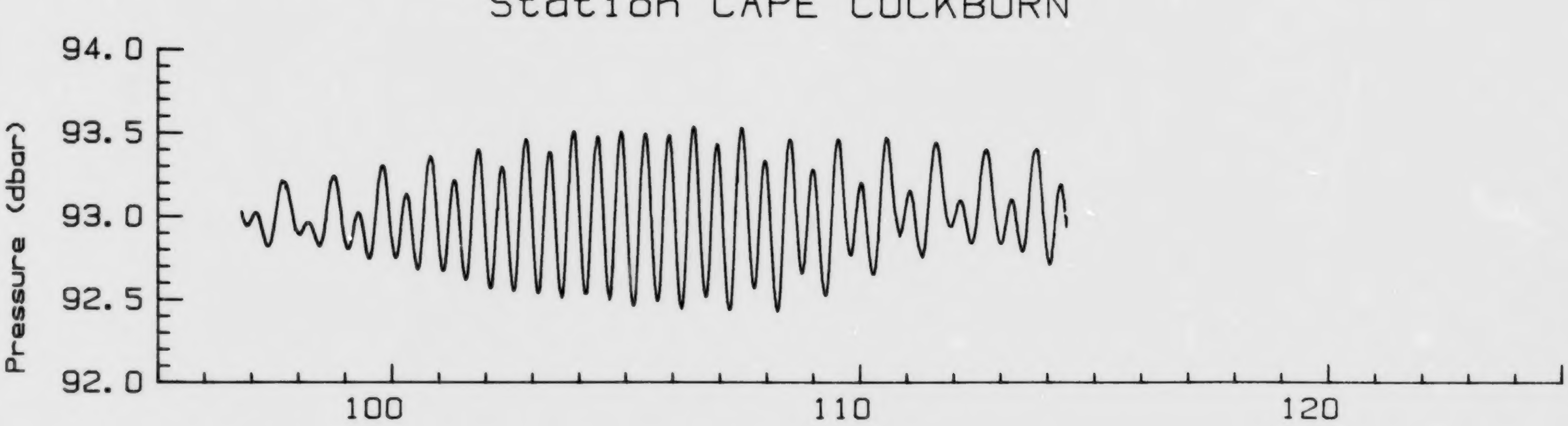


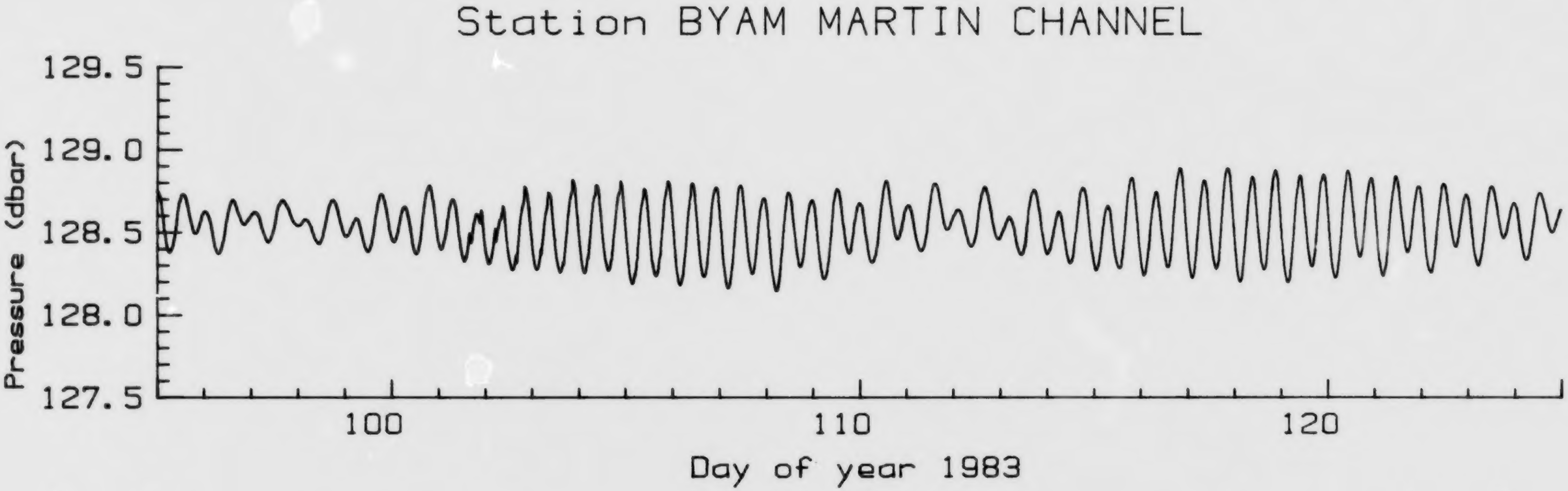
Station CM86 - 18 metres


Station CM86 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1983


Station CM87 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
90
100
110
120
Day of year 1983


Station CM87 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1983


Station CAPE COCKBURN
Pressure (dbar)
94.0
93.5
93.0
92.5
92.0
100
110
120


Station BYAM MARTIN CHANNEL
Pressure (dbar)
129.5
129.0
128.5
128.0
127.5
100
110
120
Day of year 1983

Volume

3

Current and Sea-Level Measurements in the Northwest Passage
Volume 3, March 1984 - April 1985.

W.R. Buckingham, R.A. Lake and H. Melling

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C., V8L 4B2

1987

Canadian Data Report of
Hydrography and Ocean Sciences
No. 51

Canad

Canadian Data Report Of Hydrography and Ocean Sciences

These reports provide a medium for the documentation and dissemination of data in a form directly useable by the scientific and engineering communities.

Generally, the reports will contain raw and/or analyzed data but will not contain interpretations of the data. Such compilations will commonly have been prepared in support of work related to the programs and interests of the Ocean Science and Surveys (OSS) sector of the Department of Fisheries and Oceans.

Data Reports are produced regionally but are numbered and indexed nationally. Requests for individual reports will be fulfilled by the issuing establishment listed on the front cover and title page. Out of stock reports will be supplied for a fee by commercial agents.

Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

Rapport statistique canadien sur l'hydrographie et les sciences océaniques

Ces rapports servent de véhicule pour la compilation et la diffusion des données sous une forme directement utilisable par les scientifiques et les techniciens.

En général, les rapports contiennent des données brutes ou analysées mais ne fournissent pas d'interprétations des données. Ces compilations sont préparées le plus souvent à l'appui de travaux reliés aux programmes et intérêts du service des Sciences et Levés océaniques (SLO) du ministère des Pêches et des Océans.

Les rapports statistiques sont produits à l'échelon régional mais sont numérotés et placés dans l'index à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page de titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Les établissements des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports depuis décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du Rapport n° 1 en janvier 1982.

Canadian Data Report of Hydrography and Ocean Sciences No. 51

1987

CURRENT AND SEA-LEVEL MEASUREMENTS IN THE NORTHWEST PASSAGE
VOLUME 3, MARCH 1984 - APRIL 1985.

by

W.R. Buckingham, R.A. Lake and H. Melling

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C., V8L 4B2

PREFACE

This report is the third of three data reports documenting current and sea-level measurements in the Northwest Passage of the Canadian Arctic Archipelago between March 1982 and April 1985. Each report deals with the activities undertaken during a year-long period. Analysis and interpretation of these data appear in two separate technical reports.

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ABSTRACT

Buckingham, W.R., R.A. Lake, and H. Melling, 1987. Current and Sea-Level Measurements in the Northwest Passage. Vol. 3, March 1984 - April 1985. Can. Data Rep. Hydrogr. Ocean Sci. No. 51:139pp.

A three-year program of current and sea-level measurements was undertaken between March 1982 and April 1985 in the Canadian Arctic Archipelago by the Institute of Ocean Sciences of the Department of Fisheries and Oceans. The measurements were in the form of time series, at fixed depths by self-recording instrument packages, of temperature, salinity, current speed, current direction and water pressure at the sea-floor pressure. The activities during each year of the study concentrated on a specific region of the Northwest Passage within the Archipelago. The emphasis in 1982 was on the western portion (M'Clure Strait, Prince of Wales Strait, and Viscount Melville Sound), in 1983 on the central portion (eastern Viscount Melville Sound and Barrow Strait), and in 1984 on the eastern portion (Barrow Strait and adjacent channels). This report discusses the aims of the project, the logistics of the 1984 field work, and summarizes the data acquired during that year in tabular and graphic form.

key words: Arctic Archipelago, Northwest Passage, temperature, salinity, current, tide.

RESUME

Buckingham, W.R., R.A. Lake, and H. Melling, 1987. Current and Sea-Level Measurements in the Northwest Passage, Vol. 3, March 1982 - April 1983. Can. Data Rep. Hydrogr. Ocean Sci. No. 51:139pp.

De mars 1982 a avril 1985, l'Institut des Sciences de la Mer du MPO a réalisé un programme triennal de mesures du niveau de la mer et des courants dans l'archipel arctique canadien. Ces mesures ont été prises sous forme de séries chronologiques, à des profondeurs déterminées, par des groupes d'instruments automatisés, de la température, de la salinité, de la vitesse et direction de courant et de la pression de leau au fond de la mer. Les activités annuelles ont porté sur une région déterminée du passage du Nord-Ouest de l'archipel. En 1982, l'accent a été mis sur la partie ouest (détroit de M'Clure, détroit de Prince-de-Galles, et détroit du Vicomte-Melville), sur la partie centrale en 1983 (parti est du détroit du Vicomte-Melville et détroit de Barrow), et en 1984, sur la partie est (détroit de Barrow et chenaux adjacents). Le présent rapport porte sur les buts du projet, le soutien logistique du travail sur le terrain en 1984 et résume les données recueillies cette année-là, qui sont présentées sous forme de tableaux et de graphiques.

Mots-clés: archipel arctique, passage du Nord-Ouest, température, salinité, courant, marée.

ACKNOWLEDGEMENTS

The authors wish to thank various members of the Institute of Ocean Sciences whose diligent efforts helped to make this project a success. In particular we thank electronics technician R.A. Cooke, support technician S. W. Moorhouse, and J.W. Green from the computing section. Logistic support, and accommodation at Resolute Bay was provided by the Polar Continental Shelf Project of the Department of Energy, Mines and Resources. Meals, radio and accommodations were also made available at Rae Point by Panarctic Oils, Ltd. We sincerely thank both organizations, and the particular individuals involved, for their cooperation and assistance. The considerable effort involved in the recovery in 1985 of year-long moorings in Penny Strait and Barrow Strait was provided by E.L. Lewis, R.G. Perkin, A.W. Koppel and G.A. Moonie of this Institute. This effort is gratefully acknowledged.

The funding for this project was provided by the Marine Transportation Research and Development Programme.

1. INTRODUCTION

A three-year physical-oceanographic study was undertaken between 1982 and 1985 in the Canadian Arctic Archipelago, centering on the complex of waterways known as the Northwest Passage. The study was carried out by the Department of Fisheries and Oceans at the Institute of Ocean Sciences (IOS). It extended from Amundsen Gulf in the west, through Prince of Wales Strait, M'Clure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound to Baffin Bay in the east (see Figure 1). The study also included the various passageways and basins bordering the Northwest Passage. The overall objective included the following goals:

1) the identification of the magnitude and direction of tidal and non-tidal currents,
2) the description of tidal propagation,
3) the identification of sources and destinations of various water-masses,
4) the identification of the relative importance of physical forces which determine currents and water-mass distribution (e.g. tidal forces, baroclinic forces related to horizontally inhomogeneous distribution of water density and non-tidal barotropic forces related to oceanic and atmospheric circulation),
5) the identification of temporal and spatial variability in current and water-mass distribution. Periods of particular importance are tidal (semi-diurnal and diurnal), seasonal and interannual. Also of potential importance are singular or non-periodic events such as storm surges,
6) the estimation, to an order of magnitude, of the volume of water transport into and out of the study area and the partition of that transport.

The activities during each year of the study concentrated on a specific region of the Northwest Passage. The emphasis in 1984 was on the central portion. The field operations were undertaken during the early spring months, at which time the solid ice-cover made a stable platform from which to work.

This report describes the acquisition of water-current and sea-level information in 1984/85 as time series of current, temperature, salinity and sea-floor pressure and presents the data in final processed form. The main study area comprised the Barrow Strait and adjoining channels. The relevant mooring locations are indicated by square symbols and triple parallel lines (indicating transects) in Figure 2. The tide gauges are indicated by circular symbols. Tide gauges operated by other agencies are shown as diamond symbols. Data reports covering the activities during 1982 and 1983 may be found in Volumes 1 and 2 of this report series.

A related oceanographic investigation undertaken concurrently by the Institute of Ocean Sciences on the western periphery of the Arctic Archipelago was termed the Arctic Shelf Programme. The time series from this study are not included in this report. The mooring stations for the Arctic Shelf Programme are denoted in Figure 2 by star symbols. Relevant ocean measurements were acquired concurrently by the Canadian Hydrographic Service in the Gulf of Boothia (CHS-Central: seafloor pressures). The Canadian Hydrographic Service maintains tide stations at Cape Parry and Resolute Bay, and in 1984/85 maintained stations at Mould Bay, Isachsen and Auldhild Bay.

The study area has not previously been extensively investigated due to its remoteness and to the difficulty of ship operations. The sea surface is

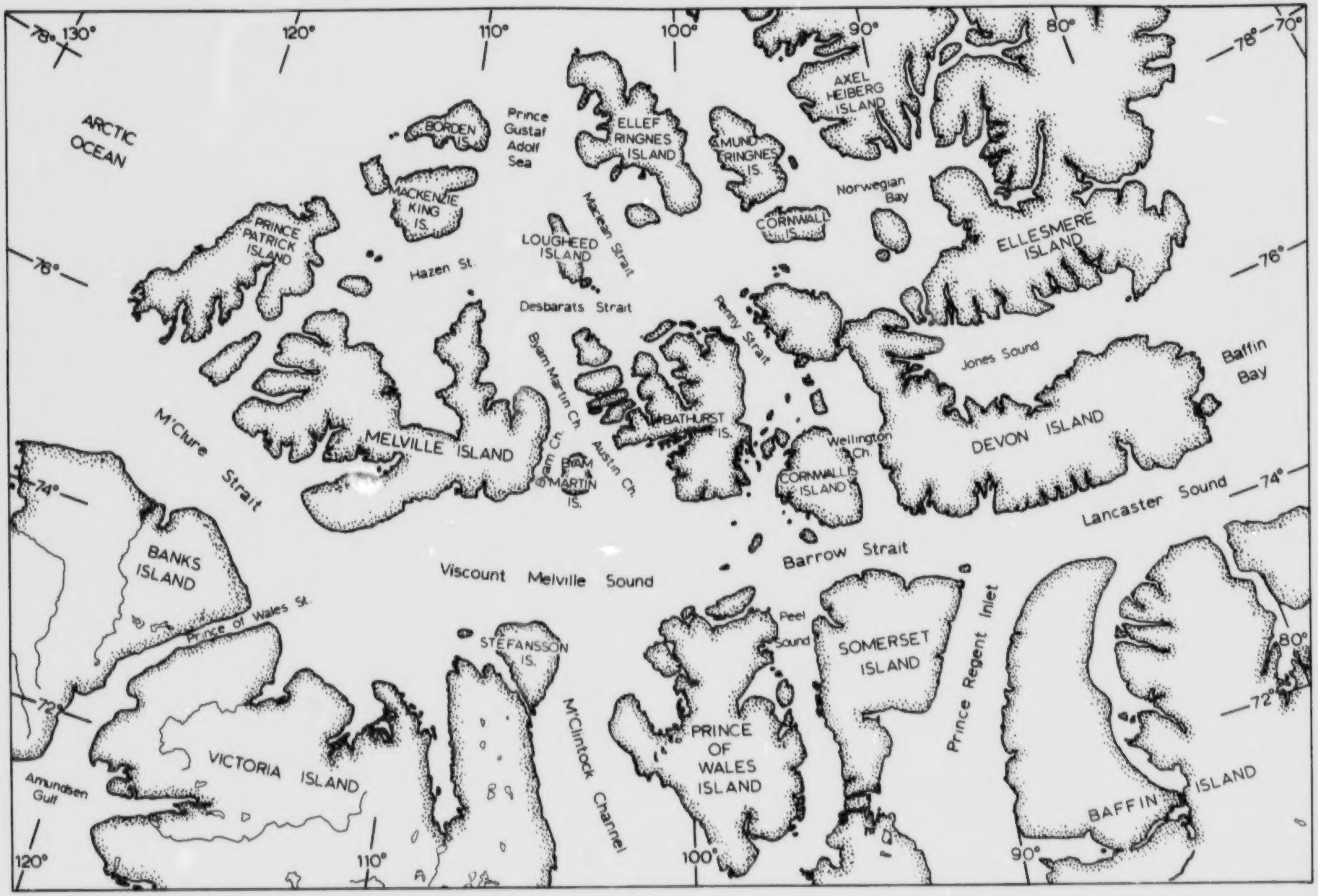


Figure 1. A map of the Canadian Arctic Archipelago. The Northwest Passage shipping route will likely be through Lancaster Sound, Barrow Strait, Viscount Melville Sound, and Prince of Wales Strait.

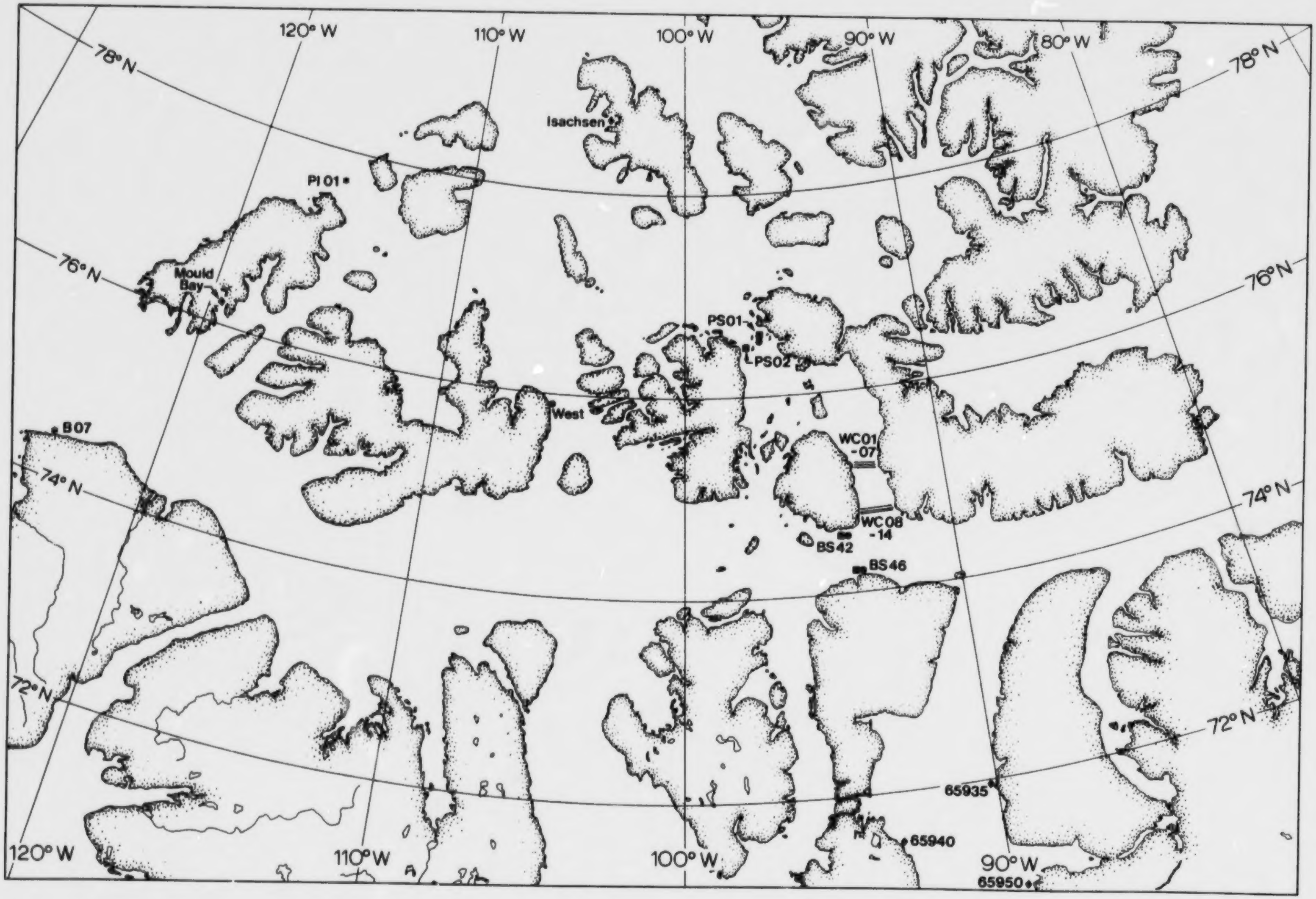


Figure 2. Location of recording instrumentation moorings throughout the Arctic Archipelago in 1984 (square and triple lines - current meters; dots - tide gauges; stars and diamonds - current meter and tide gauges from concurrent studies by other agencies).

completely frozen during most of the year, and is often ice-choked during the short navigation period. Previous oceanographic research in the Arctic Archipelago has been tabulated by Fissel, Knight and Birch (1984). The earliest significant collection of oceanographic data was accomplished from ships in summer during the 1950's and 1960's. These data were sufficient to delineate the regional water-mass characteristics. In 1976 and 1977, direct current measurements were made in Byam and Austin Channels and Crozier and Pullen Straits by the Institute of Ocean Sciences. In 1977 and 1978 investigators from the Physical Oceanographic Group of the Canada Centre for Inland Waters completed a number of current meter transects across Viscount Melville Sound, Prince of Wales Strait, and adjacent channels (Peck, 1978 and Prinsenberg, 1978). Current data across the western end of Viscount Melville Sound were gathered in 1979 as part of the Polargas Project (1979). A number of tidal height measurements were made during 1979 and 1980 as part of the Bridport Inlet studies by IOS. The Canadian Hydrographic Service made extensive tidal height measurements in 1977, and an additional tidal height record was obtained as a part of the Polargas program in 1979.

The present study involved measurements by CTD probe, recording current meters, tide gauges, and meteorological stations. This report deals with the recording instrument measurements. Section 2 describes the physical setting and bathymetry of the study area and the mooring locations during 1984/1985. Section 3 recounts the logistics, equipment used, and the timing of the measurements, while Section 4 deals with the data processing procedures. The data are presented as time-series plots in the Appendix.

2. PHYSICAL SETTING AND STATION LOCATIONS

2.1 Arctic Archipelago

The Canadian Arctic Archipelago consists of a large group of islands lying on the extensive polar continental shelf of North America (Figure 1). The Archipelago extends roughly 1500 kilometers between the 68° and 82° North latitude and about 2700 kilometers between 60° and 130° West longitude (at 70° North). These islands are bounded to the north and west by the Arctic Ocean and the Beaufort Sea respectively, to the south by the mainland of the North American continent and to the east and southeast by Nares Strait, Baffin Bay, Davis Strait, and Labrador Sea. For convenience, the Archipelago is often divided into three sections from north to south as follows: the Sverdrup Basin lying within the Queen Elizabeth islands (i.e., all islands north of Parry Channel); Parry Channel, consisting of M'Clure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound; and the "Southern Channels" comprising Amundsen Gulf, M'Clintock Channel, the Gulf of Boothia, and other, lesser waterways.

2.2 General Bathymetry

The channels and basins throughout the Archipelago are in general substantially shallower than the major adjoining oceanic basins. The continental shelf effectively limits free passage of water to maximum depths of about 450 meters into Sverdrup Basin, to about 380 metres into M'Clure Strait, and to about 360 meters into Amundsen Gulf. To the east, Baffin Bay has depths up to 2300 meters, but the sill in Davis Strait (to the south of Baffin Bay) limits deep water exchange with the North Atlantic to depths of less than 700 meters. Another shallow entrance (50 meters) to the Archipelago from the

North Atlantic exists through Hudson Strait, Foxe Basin, and Fury and Hecla Strait in the south. The deepest continuous passage through the Archipelago exists through Parry Channel and has a limiting sill of 125 meters in Barrow Strait. The passageways connecting Sverdrup Basin to the southern channels (M'Clure Strait, Viscount Melville Sound, Barrow Strait, etc.) are in general constricted by shallow sills on the order of 100 meters in depth. South of Parry Channel depths are characteristically shallow (mostly less than 200 meters) with the exception of some deeper areas of greater than 400 meters extending into Prince Regent Inlet from Lancaster Sound.

2.3 Mooring Locations and Local Bathymetry

The Northwest Passage field study in 1984 was concentrated on the region of the central sills of the Arctic Archipelago. The study area was bounded on the north by Penny Strait, on the east by the 91° West meridian in eastern Barrow Strait, on the south by Somerset Island, the northern end of Peel Sound and Prince of Wales Island, and on the west by the 106° West meridian in western Barrow Strait. Due to the large size of the area studied (about 50,000 square kilometres) currents were not measured systematically over the area. Only 2 transects were instrumented (in Wellington Channel) for the measurement of near-surface currents, and on these an attempt was made to achieve mooring spacing comparable to internal deformational, and topographic scales of variability. In anticipation of shoreline "hugging" baroclinic flows, meters were more closely spaced near shores (see Figure 2). As a result of confidence gained in the two preceding years of the project, four moorings were deployed for a 12-month period to measure seasonal variations in flow, and the vertical structure of current. Two were deployed in Barrow Strait, and two in Penny Strait. Recording pressure gauges were placed in the anchor buckets of 3 of these moorings. Two additional pressure gauges were deployed for a shorter period near the western shores of Byam Martin and Wellington Channels.

Concurrent measurements of current and seafloor pressure were acquired by the Canadian Hydrographic Service in the Gulf of Boothia. Farther afield the Canadian Hydrographic Service made sea-floor water pressure measurements at Mould Bay, Isaachsen, Auldhild Bay and Pond Inlet, in addition to continuing longterm measurements at Cape Parry, Alert and Resolute Bay. Current measurements in Ballantyne Strait and western M'Clure Strait were acquired over 12 months by DFO staff as part of the Arctic Shelf Programme (R.G. Perkin, personal communication.) These locations are plotted, where possible, in Figure 2.

Instrument location, depth, type, serial number, recovery success and observational period are tabulated for this program and for concurrent studies in Table 1.

The bathymetry of the channels in the vicinity of the instrument moorings is shown in Figures 3 and 4. Figure 3 shows the waters surrounding Cornwallis Island. The principal sill of the Northwest Passage lies southwest of Lowther island near 98° W, 74.4° N (125 m). Other significant sills are found at the northern and southern ends of Wellington Channel, and at the southern end of Penny Strait. Figure 4 shows the topography of the latter strait to be complex. Waters within and immediately to the south of the strait are quite deep (~300 m). Waters in the Peel Sound also exceed 200 m.

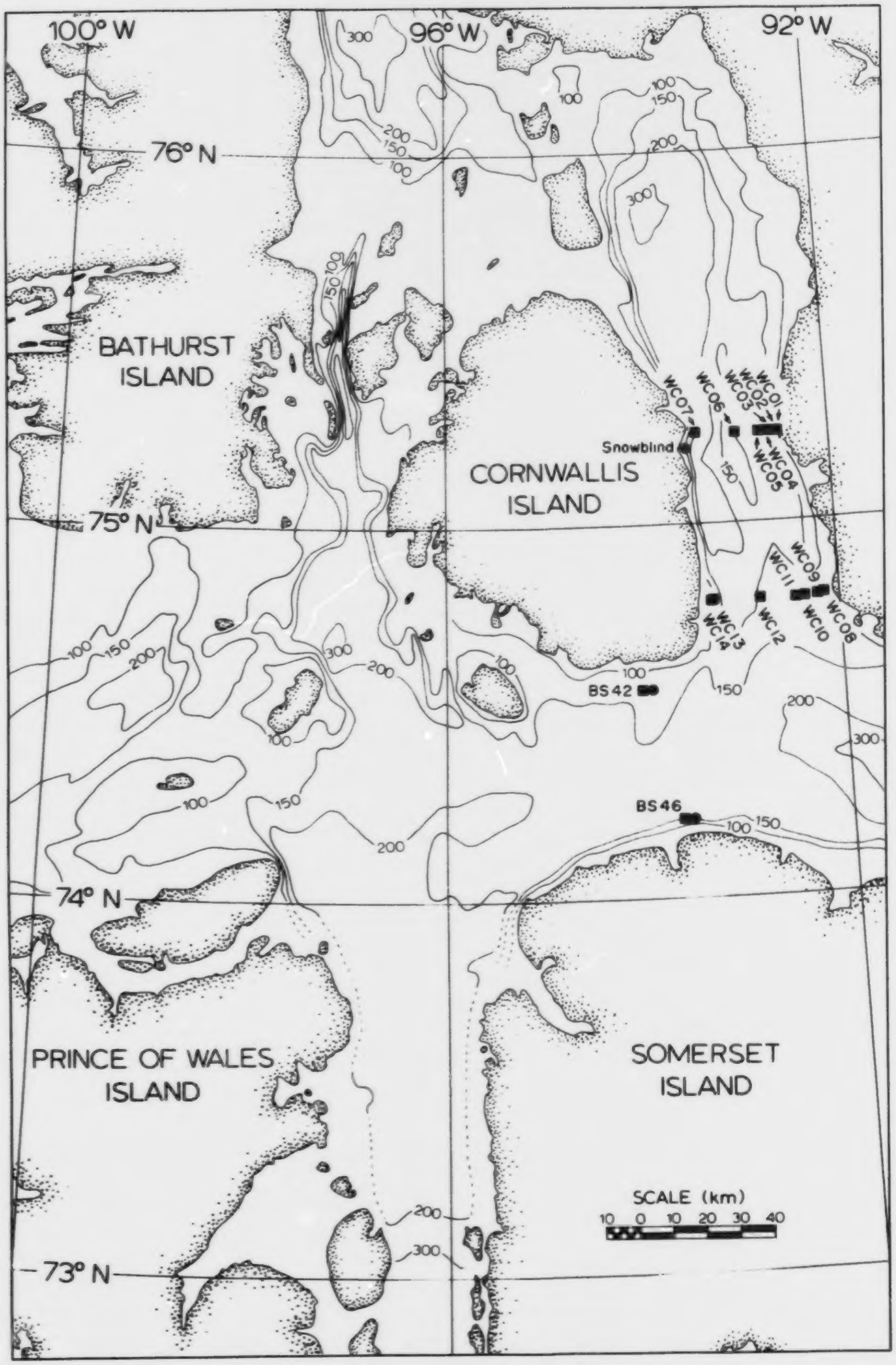


Figure 3. Bathymetry of the channels in the vicinity of Cornwallis Island (squares - current meters; dots - tide gauges).

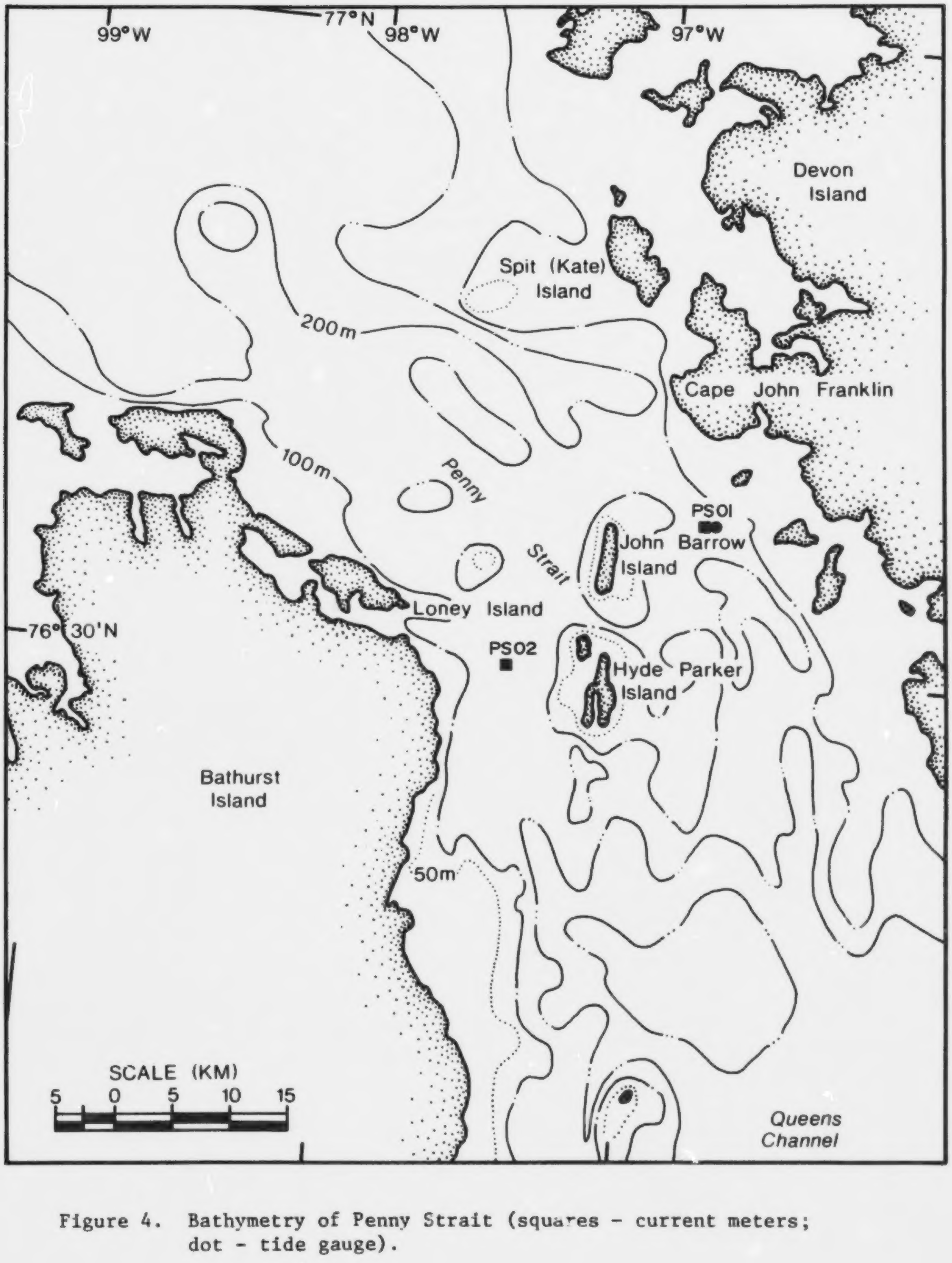


Figure 4. Bathymetry of Penny Strait (squares - current meters; dot - tide gauge).

In the following table, CCIW = Canada Centre for Inland Waters, T and C = Tides and Currents Section of Fisheries and Oceans, CHS = Canadian Hydrographic Service.

Table 1. Summary of Recording Instrument Records

Region	Site	S/N	Latitude	Longitude	Type	3 mos.	12 mos.	Depth (m)	Data Recovery/ Remarks	
Wellington Channel	WC01	0801	75°13.3'	92°31.7'	RCM4	✓		18	✓	
"	WC02	0972	75°14.1'	92°33.8'	RCM4	✓		18	✓	short record
"	WC03	1930	75°14.1'	92°35.4'	RCM4	✓		18	✓	
"	WC04	1931	75°14.1'	92°40.0'	RCM4	✓		18	✓	
"	WC05	2687	75°14.4'	92°44.4'	RCM4	✓		18	✓	
"	WC06	2686	75°14.4'	92°59.6'	RCM4	✓		18	✓	
"	WC07	3228	75°15.2'	93°22.8'	RCM4	✓		18	✓	
"	WC08	3223	74°47.7'	92°09.2'	RCM4	✓		18	✓	
"	WC09	1305	74°47.6'	92°12.7'	RCM4	✓		18	x	instr. malf'n.
"	WC10	1932	74°47.5'	92°21.6'	RCM4	✓		18	✓	
"	WC11	1939	74°47.8'	92°27.8'	RCM4	✓		18	✓	
"	WC12	0218	74°47.7'	92°48.1'	RCM12	✓		18	✓	
"	WC13	0217	74°47.7'	93°17.8'	RCM12	✓		18	✓	
"	WC14	2695	74°47.7'	93°18.0'	RCM4	✓		18	x	instr. malf'n.
Barrow Strait	BS42	0211	74°34.2'	94°01.2'	RCM12	✓		18	x	exp'tl. AML RCM; malfunction.
"	BS42	0215			RCM12	✓		18	x	exp'tl. AML RCM; malfunction.
"	BS42	0216			RCM12	✓		18	x	speed missing
"	BS42	1386			RCM4	✓		18	✓	
"	BS42	3388			RCM4		✓	51	✓	
"	BS42	1935			RCM4		✓	100	✓	
"	BS46	1936	74°12.5'	93°46.8'	RCM4	✓		18	✓	
"	BS46	4960			RCM4		✓	52	x	
"	BS46	0800			RCM4		✓	101	x	lost
"	BS46	3395			RCM4		✓	149	x	lost

Table 1. Summary of Recording Instrument Records (Continued)

Region	Site	S/N	Latitude	Longitude	Type	3 mos.	12 mos.	Depth (m)	Data Recovery/ Remarks
Penny Strait	PS01	5361	76°38.7'	96°54.6'	RCM4		✓	43	✓
"	PS01	5456			RCM4		✓	131	✓
"	PS02	5391	76°36.2'	97°25.2'	RCM4		✓	49	✓
"	PS02	5471			RCM4		✓	138	✓
Ballantyne Strait	PI01	5474			RCM4		✓	35	✓
"	PI01	5473			RCM4		✓	83	✓
M'Clure Strait	B07	4182			RCM4		✓	35	✓
"	B07	5472			RCM4		✓	96	✓
Byam Martin Channel	West	0087	75°54.9'	105°36.2'	TG12A	✓		27	✓ P_{max} = 30 dbar
Wellington Channel	Snowblind	0086	75°12.6'	93°29.6'	TG12A	✓		14	✓ P_{max} = 30 dbar
Penny Strait	PS01	0080			WLR5A		✓	186	✓ P_{max} = 270 dbar
Barrow Strait	BS42	0366			TG5		✓	129	✓ P_{max} = 270 dbar
"	BS46	0114			TG12A		✓	160	x lost
Auldhild Bay CHS					TG		✓		✓
Isachsen Bay CHS					TG		✓		✓

3. DATA COLLECTION

3.1 Instrumentation

In total, 28 recording current meters and 15 recording pressure gauges were deployed in April 1984 within the study area delineated in Section 2.3. Of the current meters, 19 were suspended from the ice for a deployment of between one and three months at shallow depth (~20 m). These meters were Aanderaa Instruments Ltd. RCM4's, modified at the Institute of Ocean Sciences to the 'vane-follower' configuration described below, or Applied Microsystems Ltd., CM12's (5 units). Three of these were deployed for engineering purposes and their records will not be discussed here. The remaining 9 current meters were also Aanderaa RCM4's deployed in the 'vane follower' configuration, and were used on the 12-month deployments in Barrow and Penny Straits, where stable ice for suspension could not be expected throughout the deployment. Mesotech acoustic releases (Model 501AR) were used to secure the subsurface moorings in Barrow and Penny Straits. Recording pressure gauges were manufactured by Aanderaa Instruments, Ltd. (Model WLR5A) or by Applied Microsystems, Ltd. (TG12A). All gauges use the Paroscientific, Inc. Digiquartz pressure transducers, with a full-scale pressure ranges as indicated in Table 1.

Special modification to the RCM4's was as follows: Two or more of the resistors in each of the bridge circuits for temperature and conductivity ratio were exchanged for values yielding 10-bit resolutions of about 0.005°C and 0.00016 respectively, and ranges centred on those of interest. For temperature this range was typically (-2.5°C, +2.5°) and for salinity approximately (29, 35). Resolution in salinity was about 0.006. Aanderaa current meters were deployed in lengthened pressure cases which permit the installation of two batteries, desireable for long records at low water temperature. In the 'vane follower' configuration, a small (8.7 cm high by 5.8 cm wide) vane was suspended beneath the pressure case in mounts held by 3 stainless steel rods about 6 mm in diameter. The vane was neutrally buoyant in seawater. The field from two magnets mounted above the vane and free to turn with it was adequate to orientate the compass within the case. In this way current direction relative to the case was measured, while geographic orientation of the case was established at deployment and maintained until recovery.

Three methods were used for positioning moorings. Pressure gauge moorings near shore were sited by sextant relative to natural landmarks, or to markers set up for the purpose. Moorings more than a few hundred meters from shore were positioned using a GNS-500A VLF/Omega navigation system installed on the aircraft and initialized at nearby geodetic survey points. This allowed positioning to within a 500 m radius. The bottom-founded moorings in Barrow and Penny Straits were positioned to an accuracy of a few meters using microwave transponders (a DelNorte system) deployed at known locations for this purpose. Sites where moorings were to be recovered before the break-up of fast ice in summer were marked by 4-foot square by 1-foot high aluminum marker boxes painted red, and by radio beacons operating at 130 MHz (Novatech Designs Ltd., Model RF200). Sites where moorings were to be recovered one year later were marked by underwater acoustic beacons operating at 37 kHz (Johnson Laboratories, Inc., Model JL1).

3.2 Mooring Design, Deployment and Recovery

'Vane-follower' current meters were suspended from the sea ice on 1-inch hydraulic hose (see Figure 5). The hose was chosen because of its high torsional rigidity despite reasonable bending flexibility. Resistance to twisting was essential for maintaining a direction reference for current measurement. Meter depth was 18.5 m below the upper ice surface for all near-surface instruments. The hose was terminated and bolted to a 1-inch aluminum pipe just below the ice. This 12-foot pipe, and a vinyl-coated cable within it passed through the ice inside a 10-foot pipe of polyvinyl chloride plastic (PVC). A rubber seal between the metal and PVC pipes at the lower end of the latter permitted the space between the pipes to be filled with a 50/50 ethylene-glycol/water solution. A crossbar at the top of the metal pipe held the weight of the mooring and allowed mooring orientation (and that of the current meter) to be established. The assembly was deployed through an 8-inch-diameter hole augered in the ice and allowed to freeze in. The plastic-coated cable was bolted to the square site marker as a security measure. At the time of recovery, an 8-inch hole was augered beside the mooring and the crossbar on the mooring removed. The metal pipe was then lowered on the cable until well clear of the ice. At this point, the cable was hooked by a pole manipulated through the adjacent hole and the assembly pulled through this hole to the surface. The PVC pipe (still frozen in the ice) was abandoned. Simulation of the mooring response to flow using the model of Bell (1979) indicated that the vertical displacement of the current meter was only 0.2m with a 50 cm/s current.

Current meters in 'vane-follower' configuration were also used at sites BS42 and BS46 in Barrow Strait and PS01 and PS02 in Penny Strait on the bottom-founded moorings (see Figure 6). Flotation was provided by a single 28" diameter steel float (Ocean Reasearch, Inc., Model SS28). The principal mooring "line" was assembled on site from aluminum tubing (12-foot lenths) of 1" diameter. Current meters were mounted in load-bearing frames made from two 1/2"-diameter stainless steel rods spread to a separation of 8" to allow inclusion of the RCM4. Frames were about 4 feet in length and were bolted in line with the tubing. The anchor consisted of steel chain lengths contained in a 45-gallon drum with a harness of steel flat stock to reinforce it. Steel feet penetrated the sediment to discourage anchor movement. The mooring was attached to the anchor via a universal joint from an automobile which permitted bending in any plane, but no twisting. The overall intent of the design was to achieve a high degree of torsional rigidity while allowing bending. Magnetic compasses could not be used at these sites for direction reference due to the weak horizontal geomagnetic field. Orientation of the moorings was determined at deployment using a gyrocompass. A single acoustic transponding release was used on each mooring. Current meters were positioned at depths near 50 m, 100 m and 150 m. Pressure records from the uppermost RCM4's indicated that 2 of the 3 moorings recovered were somewhat lacking in buoyancy. The east and west moorings in Penny Strait were depressed by 26 m and 50 m at spring tide, respectively. At BS42, depression was 5 m. The deployment winch, quadripod, ice-hole melter and other mooring gear were designed and built at the Institute of Ocean Sciences to meet the requirements of the task, and yet be aircraft transportable.

Recording pressure gauges were moored in two ways. Those gauges required for tidal description, and short-term (1-3 month) deployment were strapped above a steel or lead ballast weight and lowered to an upright position on the seafloor (see Figure 7). Sufficient slack was left in the

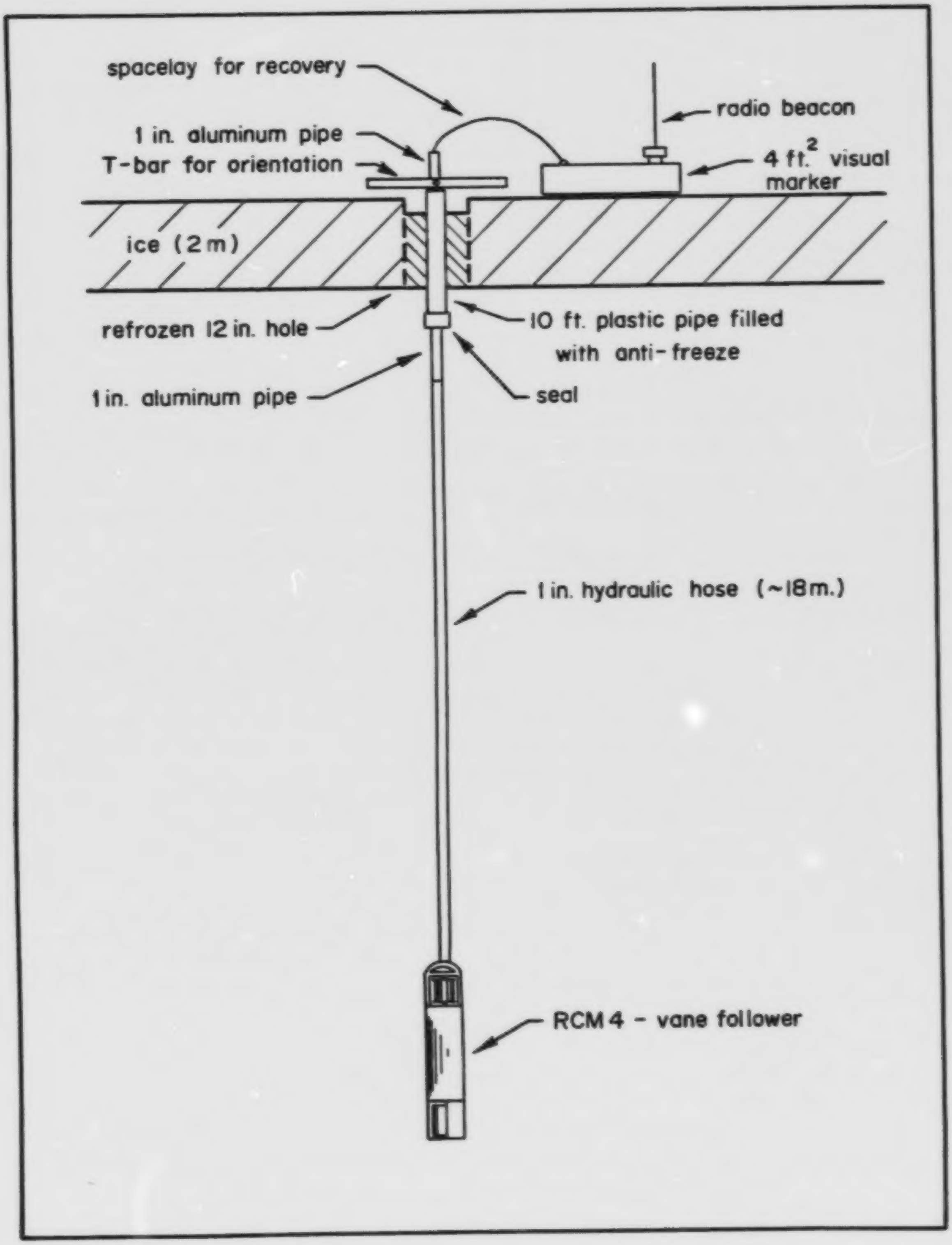
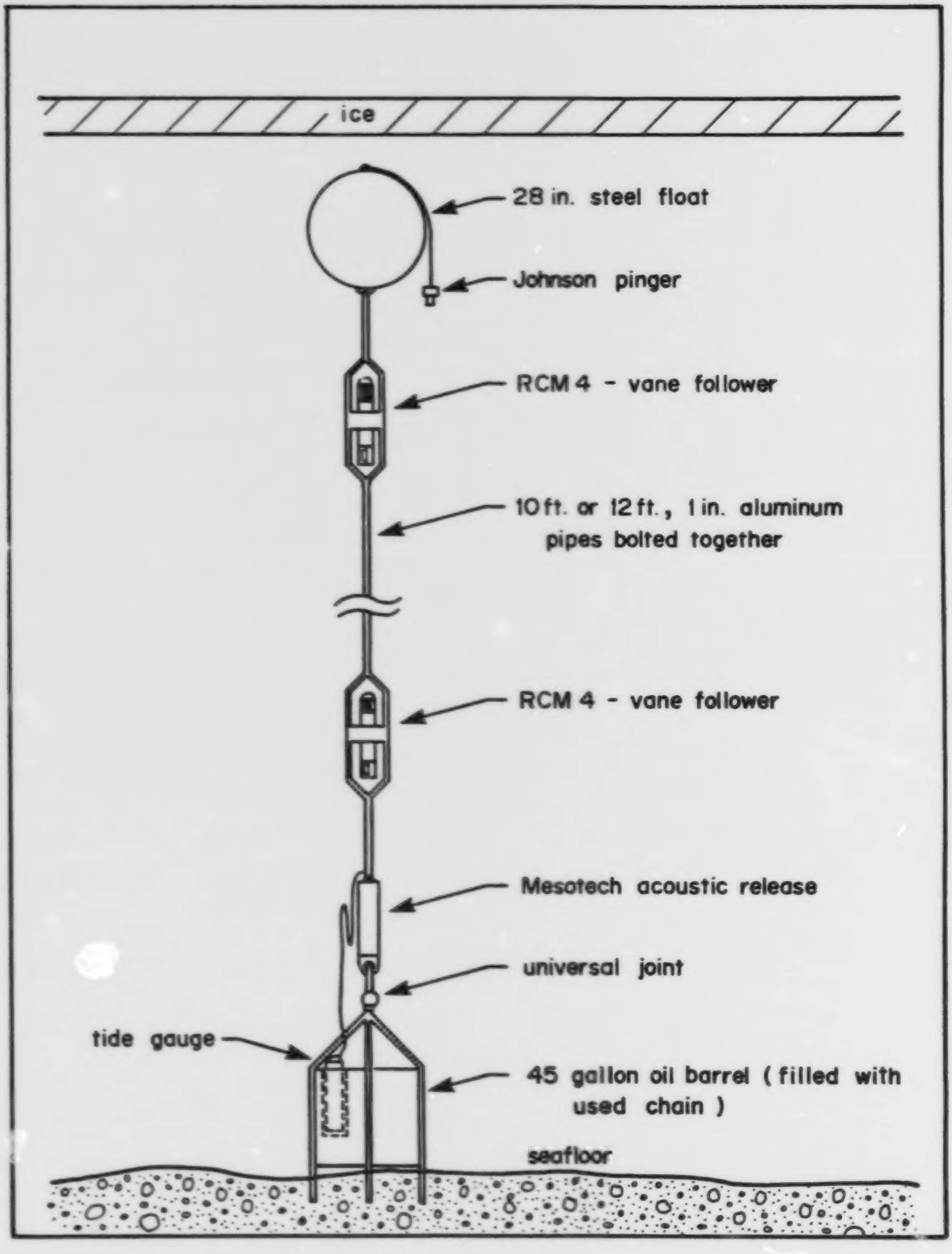


Figure 5. Vane-follower current meters suspended from the sea-ice on hydraulic hose.



ice
28 in. steel float
Johnson pinger
RCM 4 - vane follower
10 ft. or 12 ft., 1 in. aluminum pipes bolted together
RCM 4 - vane follower
Mesotech acoustic release
universal joint
tide gauge
45 gallon oil barrel (filled with used chain)
seafloor

Figure 6. Bottom founded mooring with vane-follower current meters.

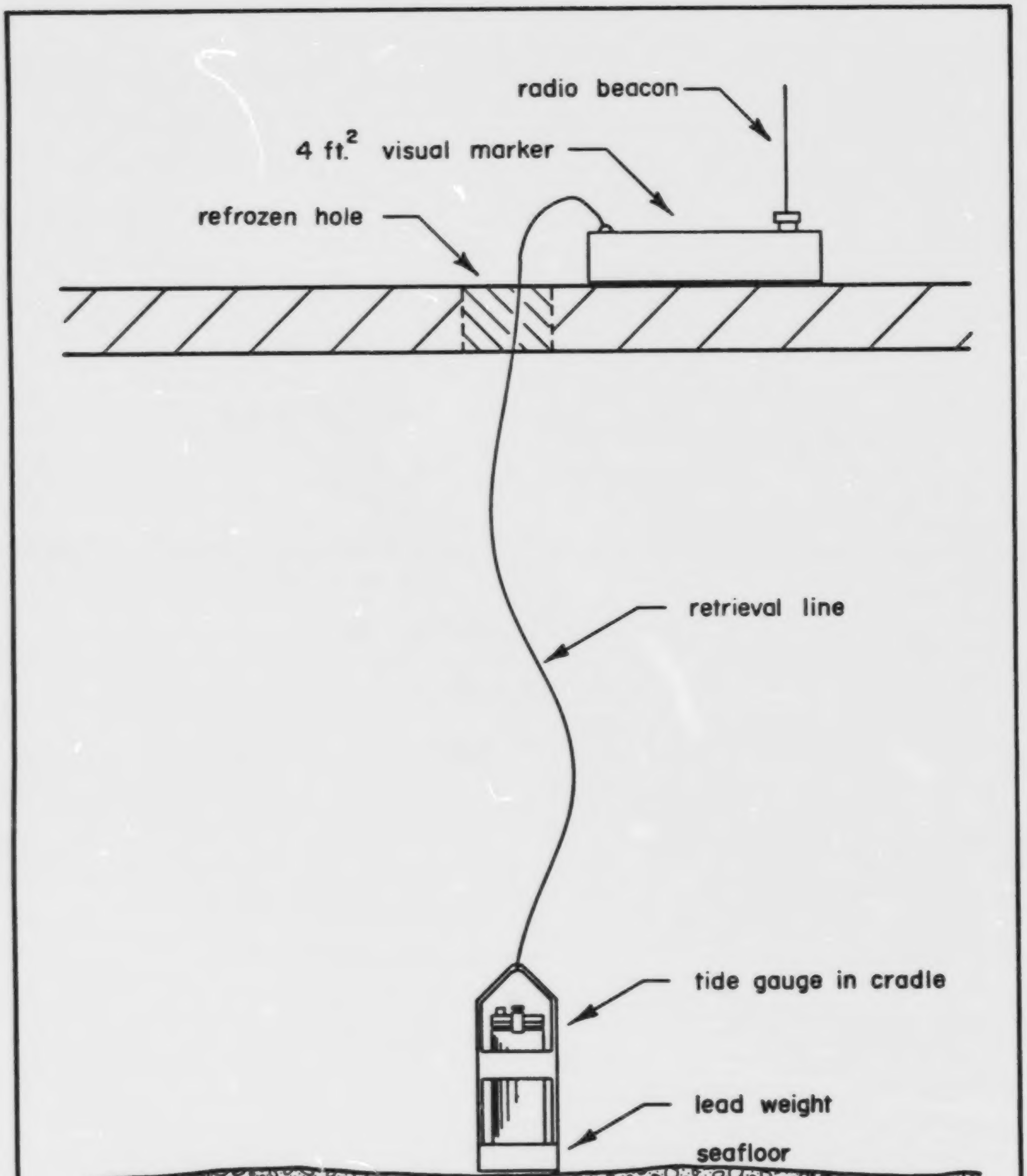


Figure 7. Mooring for short-term tide gauge deployment.

polypropylene rope to accommodate sea-level variations, and the rope was secured to the marker barrel on the ice. For recovery, a hole was augered in the ice adjacent to the in-frozen rope, the rope hooked and the instrument raised from the seafloor. For the gauges moored in Barrow and Penny Straits over 12 months, a cradle was welded to the anchor bucket of the RCM mooring. A slack line connected the mooring to the gauge in order that the mooring, when released, would also raise the gauge to the surface.

Mooring operations were conducted, interspersed with CTD work, during the month of April 1984. Activity was supported out of a base camp run by the Polar Continental Shelf Project of the Department of Energy, Mines and Resources at Resolute Bay. Most operations were carried out from a chartered Bell 206L-1 helicopter, while caches of fuel and equipment were established in the working areas by deHavilland DHC-6 Twin Otter on ski/wheel gear.

Recovery of ice-secured instruments was accomplished during the first week of June 1984, again using a Bell 206L-1 with Twin Otter support.

Retrieval of bottom-mounted instruments was attempted in mid-April 1985, using a Twin Otter assisted by a Bell 206B helicopter for transport. A search for the release transponder was conducted in the vicinity of each mooring by lowering a hydrophone through an augered ice hole and transmitting an interrogation message. Once the transponder was heard, and was verified to be a suitable range (less than a few hundred metres), the appropriate release code was transmitted. The exact location of the released mooring was then determined by triangulation on the signal from the Johnson acoustic pinger, now close beneath the ice, and verified by physical contact on the mooring with a pole manipulated through a small augered ice hole. At this time, equipment for melting a 30-inch diameter hole through the ice, and for raising the mooring was flown to the site, by helicopter sling if necessary. Recovery then proceeded in a straightforward fashion. Unfortunately, the mooring in the southern side of Barrow Strait (BS46) could not be located. Erroneous positioning on deployment, a defective release/transponder or drift of the mooring from the site are possible explanations for its apparent disappearance. The latter explanation gains credence from the fact that the three recovered moorings were noted to be severely corroded in the vicinity of the release hook. In fact, at the mooring on the west side of Penny Strait, the hook corroded completely and the mooring floated to the surface and lodged beneath the fast ice six days before recovery was attempted. Complete corrosion of the hook may also have occurred at BS46, and current and drift ice could subsequently have moved the free-floating mooring far from its deployment position. Lack of adequate electrical isolation of the steel anchor from the aluminum release was the cause of the excessive corrosion observed. Three current meters and one tide gauge were lost at BS46.

The timing of successful operational periods of the recording instrumentation is shown in the bar chart of Figure 8.

3.3 Calibration

Current meters were deployed with sensors for current speed, direction, water temperature and conductivity. The speed sensors were not calibrated for this deployment, since experience has shown the calibration to be stable provided that rotor bearings are well maintained. Rotor thresholds were verified to be within tolerance by testing for rotation in response to a minimum torque specified by Aanderaa Instruments. It should be noted that in the 'vane follower' configuration, flow may approach the meter from any direction. (In the standard configuration flow is always at right angles to the

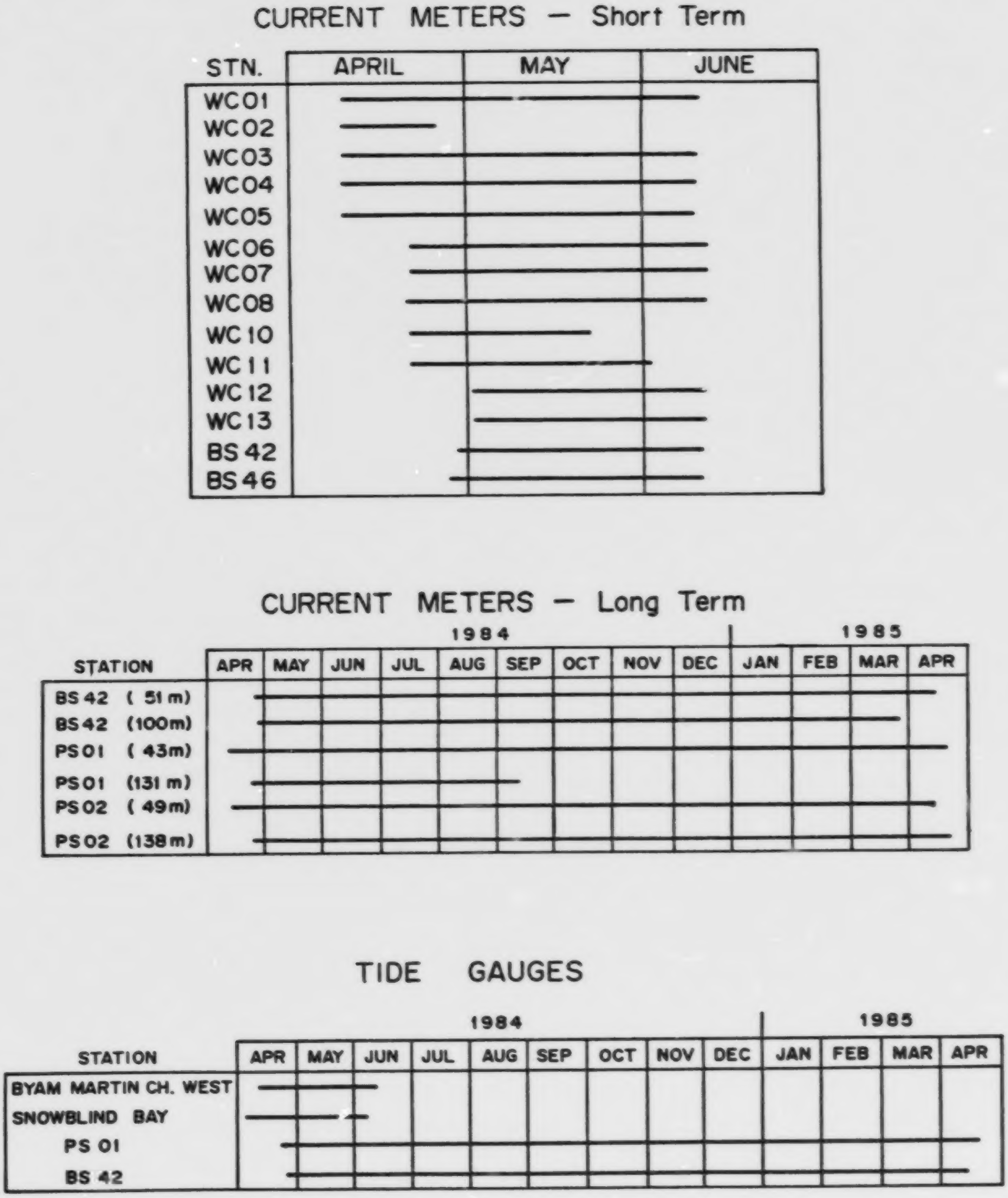


Figure 8. Bar chart of operational periods for recording instrumentation.

rotor support yoke). It has recently been established (Pite, 1986) that in some directions, the support interferes significantly with the rotor response to flow. As a result the rotor sensitivity is azimuthally non-uniform (see Figure 9). Further anisotropy is contributed by the presence of the load-bearing rods of the RCM mounting frame. Since no correction for these effects were made in processing these data, they contribute an imprecision of about ±7%.

In the 'vane-follower' configuration uncertainties in direction measurement arise from the following sources: nonlinearity in vane response to current; non-linearity in encoded compass reading to vane position; inaccuracy in carrying the reference direction up the 20 m of hydraulic hose and aluminum pipe from the instrument case to the crossbar at the surface; and inaccuracy in referencing the crossbar orientation to geographic north. The nonlinearity in vane response to current arises from the interaction of the flow with the 3 rods supporting the vane bearing and the thicker rods supporting the current meters (Pite, personal communication). Vane orientations aligned with a downstream support rod are avoided. Since no correction has been made for this effect in processing these data, an imprecision of about ±7° in direction is thereby contributed. The non-linearity in compass response to vane position arises from the interference of the geomagnetic field and any remnant magnetism in the instrument case with the magnetic coupling between the vane magnets and the compass, from any departure in concentricity between the vane and the compass pivots and from nonlinearities in the compass potentiometer. The combined effect of these factors was measured near the mooring sites before deployment (at Resolute Bay), and appropriate corrections (as large as 13° peak-to-peak) were made during processing. The uncertainty in these corrections contributes a further imprecision of ±3° to direction measurement. Difficulties in carrying the direction reference from the current meter to the crossbar produce an inaccuracy of about ±5°, while those in referencing the crossbar orientation to geographic north produce a further inaccuracy of about ±3°. (Crossbar orientation was determined by measuring the angle between the crossbar and the sun with an astrocompass, and by determining the solar azimuth from sun tables, knowing the measurement time and position). For the long pipe moorings, accuracy and precision are less good. A mooring in 150 m of water contains about 32 lengths of tubing. It is not unreasonable to assume that bolt holes at opposite ends of each length are misaligned with a root-mean-square misalignment of 5°. If these misalignments are random, then the uncertainty over 32 lengths grows to about ±30°. In addition the mooring may be subject to elastic torsional deformation. An investigation of this possibility over a 30 m length of mooring at mid-latitude where direction could be measured independently by magnetic compass gave a root-mean-square discrepancy between the 2 methods of ±5° for currents peaking at 50 cm/s. If this discrepancy scales linearly with the length of mooring, then an imprecision of ±15° - 20° from this source may be estimated for the pipe moorings deployed in 1984-85.

Temperature sensors on the current meters were calibrated in a large insulated seawater bath whose temperature was controlled to within one or two millidegrees Celsius. Sensor output was determined at 6 or 7 temperatures spanning the range, and a cubic polynomial equation for temperature fitted. Bath checks before and after deployment, and *in situ* comparisons with output from a profiling CTD have verified that accuracy and precision equal the resolution of 0.005°C.

Conductivity sensors on the current meters were calibrated in the same bath at two or three different conductivities and a linear equation for

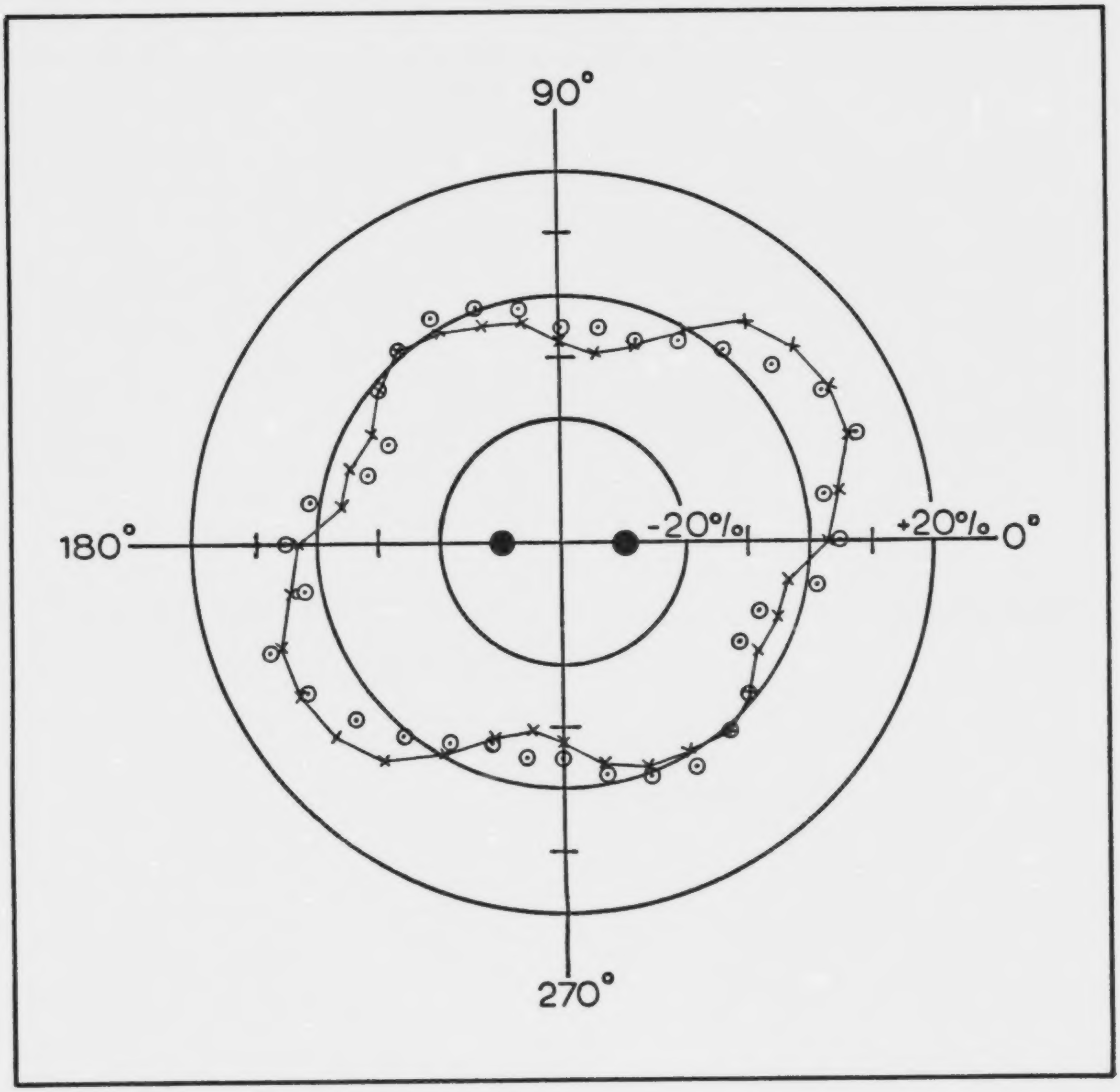


Figure 9. Plot of current meter rotor sensitivity versus azimuth for a a two rod support configuration.

conductivity ratio was fitted. Bath salinity was determined by analysis of samples on a Guildline AutoSal salinometer. Experience has shown that bath calibrations are not reliable predictors of *in situ* performance, for reasons which are not well understood. *In situ* comparisons with output from a profiling CTD at the moorings in Prince of Wales Strait in 1982 showed RCM salinity offsets ranging as far as +0.13 from laboratory calibrations, with an average departure of +0.06. *In situ* comparisons at the other moorings were not as well controlled, but yielded similar values. Calibration equations for measurements in 1984 were not, however, adjusted in accordance with the *in situ* calibrations. Accuracy and precision in salinity measurements are thus estimated to be ±0.1 and ±0.03, respectively.

Digiquartz pressure gauges were calibrated by Aanderaa Instruments Ltd., at a single fixed temperature (generally 0°C) by applying known pressures with a dead-weight tester (Ruska Model 2465-751-00). Output values at 10-20 different pressures were fitted to a polynomial equation with a precision of approximately 0.01% fs. Reproducibility of deadweight pressures was about 0.01 dbar. Their absolute accuracy depends on the care used in operation and on the attention paid to such factors as hydraulic heads and air bubbles in connecting tubing. A realistic estimate is 0.03 db.

Digiquartz pressure gauges were calibrated by Aanderaa Instruments Ltd., at a single fixed temperature (generally 0°C) by applying known pressures with dead-weight tester (Ruska Model 2465-751-00). Output values at 10-20 different pressures were fitted to a polynomial equation with a precision of approximately 0.01%fs. Reproducibility of dead-weight pressures was about 0.05 dbar. Their absolute accuracy depends on the care used in operation and on the attention paid to such factors as hydraulic heads and air bubbles in connecting tubing. A realistic estimate is 0.03 db.

The estimated accuracy and precision of the current meter and tide-gauge sensors are tabulated in Table 2.

Table 2

Estimated Accuracy and Precision of Measurement

Instrument	Parameter	Accuracy	Precision	Resolution
RCM4	Speed (cm/s)	±2%	±7%	.05 cm/s
RCM4 (hose)	Direction (°T)	±3 °	±7°	0.4°
RCM4 (pipe)	Direction (°T)	±30°	±20°	0.4°
RCM4	Temperature (°C)	±.005	±.005	0.005
RCM4	Conductivity Ratio	±.0025	±.0008	0.00016
WLR5A	Pressure (db)	±0.03db	±.005db	0.001%fs
TG12A	Pressure (db)	±0.03db	±0.005db	0.001%fs
TG12A	Temperature (°C)	±.005	±.005	±.005

4. DATA PROCESSING

The first stage in processing the current meter data was the translation of the information from the original one-quarter inch magnetic tape onto a computer-compatible nine-track magnetic tape. This process was done at the

Institute of Ocean Sciences using an HP2100 computer. The data were then read into the Institute's Univac 1100/60 computer for editing. The editing procedure involved timing checks, the truncation of irrelevant pre- and post-deployment data, and the replacement of occasional spurious measurements, or "spikes". Calibration formulae were then applied to the "N" numbers to produce values of the designated parameters, usually speed (cm/sec), direction (degrees True), conductivity ratio, temperature, and sometimes pressure. Salinity and density were then calculated. Salinity was calculated using the Practical Salinity Scale 1978 (Lewis, 1981). Density was presented as sigma-t, from the relationship,

$(\sigma_t = (\text{density } (\text{gm/cm}^3) - 1) \times 10^3)$

After the data had been converted to real values, they were stored on magnetic tape. Each file on a tape contains information from one instrument. The files begin with a header which indicates such things as instrument number, station location, and station designation. These are followed by up to eleven channels of calibrated data as follows:

channel 1 - time
2 - speed
3 - direction
4 - high resolution temperature
5 - salinity
6 - pressure
7 - conductivity ratio
8 - sigma-t
9 - low resolution temperature
10 - time code generator
11 - voltage reference

Not all channels were used in each instance.

Similar procedures were used to process the tide gauge and meteorological station data.

5. DATA PRESENTATION

The calibrated and corrected current meter data are presented in the Appendix as time series plots of current speed, direction, temperature, and salinity. Superimposed on the speed and direction traces with a heavier pen are low-pass filtered values of the same (tidal signal removed). One month of data is displayed per page.

For the tide-gauge measurements, only one month of representative data is shown.

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APPENDIX

Recording instrument data index and time-series plots.

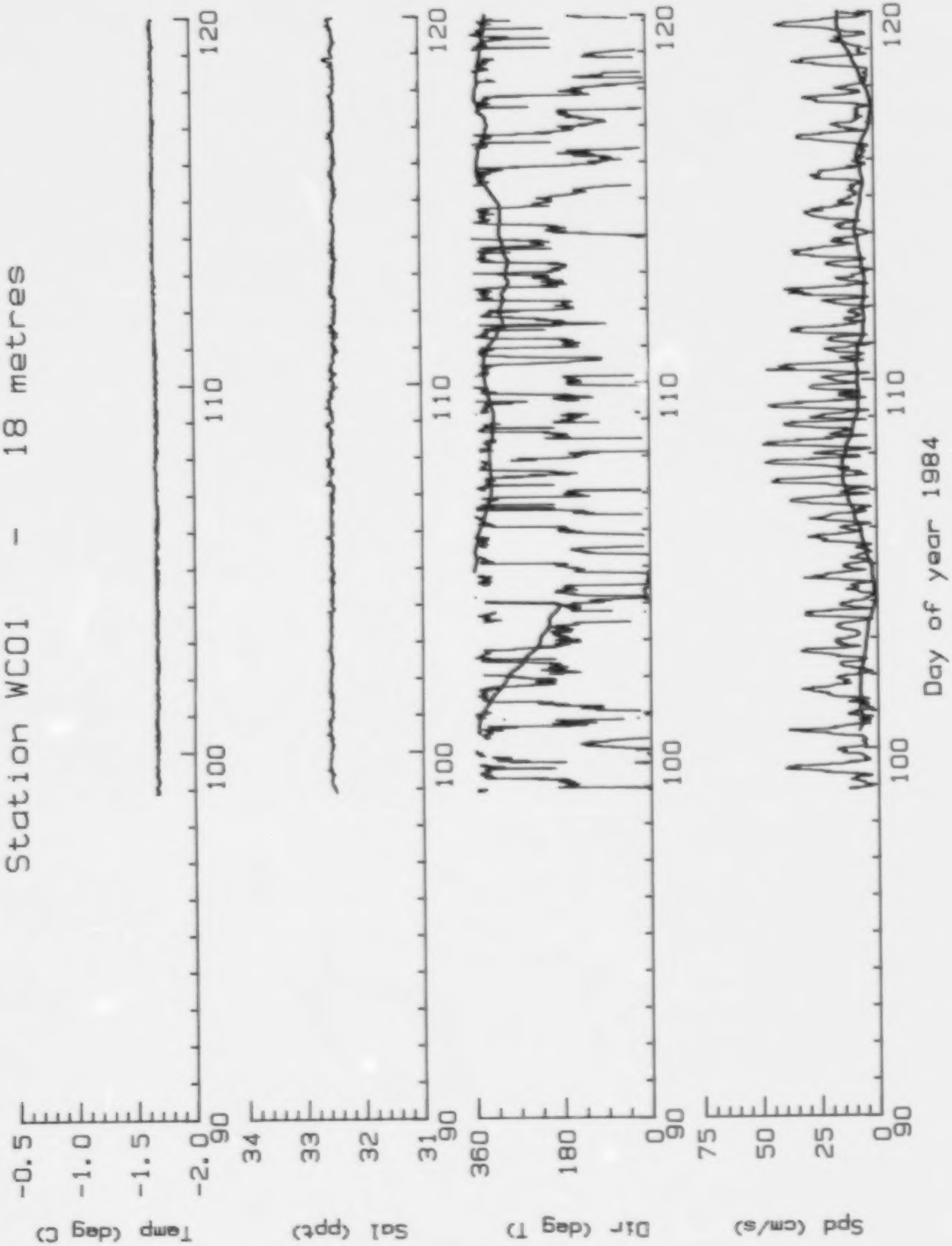
RECORDING INSTRUMENT DATA INDEX

CURRENT METERS

STATION	PAGE
WC01	24
WC02	27
WC03	28
WC04	31
WC05	34
WC06	37
WC07	40
WC08	43
WC10	46
WC11	48
WC12	51
WC13	53
BS42 - 18m	55
BS42 - 51m	58
BS42 - 100m	71
BS46	83
PS01 - 43m	86
PS01 - 131m	99
PS02 - 49m	112
PS02 - 138m	125

TIDE GAUGES

STATION	PAGE
Byam Martin Channel West	138
Snowblind Bay	138
PS01	139
BS42	139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-2.0
Sal (ppt)
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33
32
31
Dir (deg T)
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180
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Spd (cm/s)
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25
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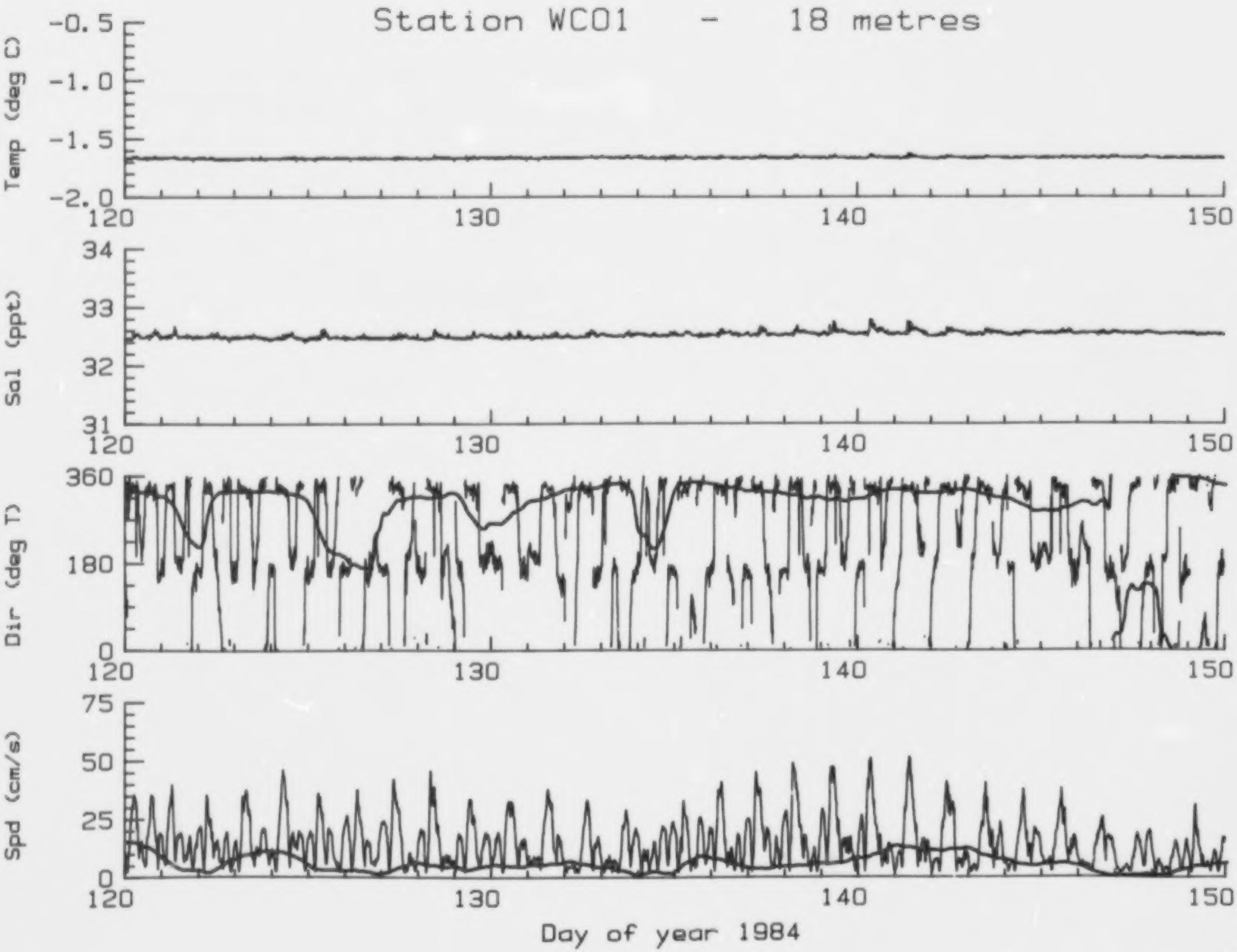
90
100
110
120
Day of year 1984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Spd (cm/s)
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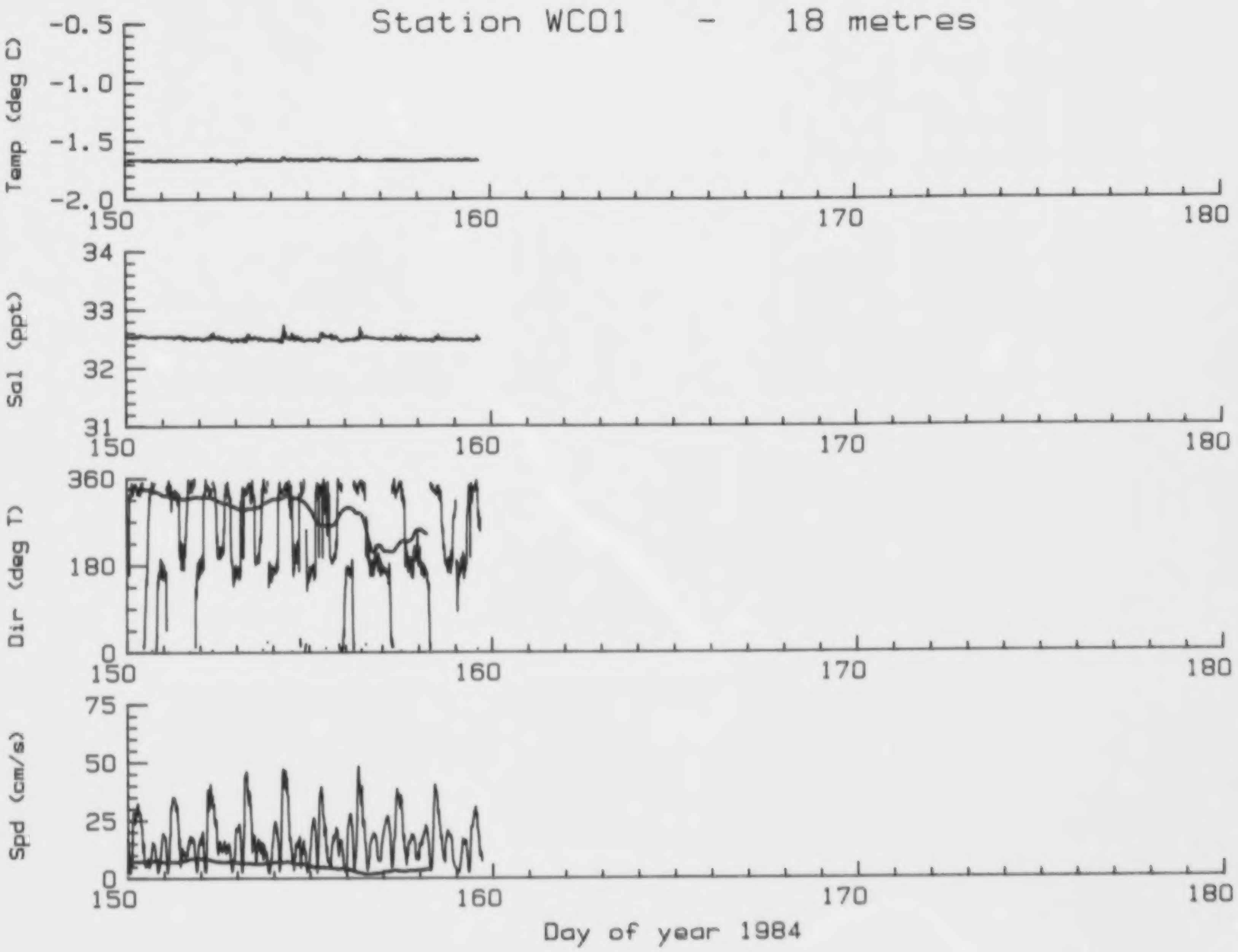
Day of year 1984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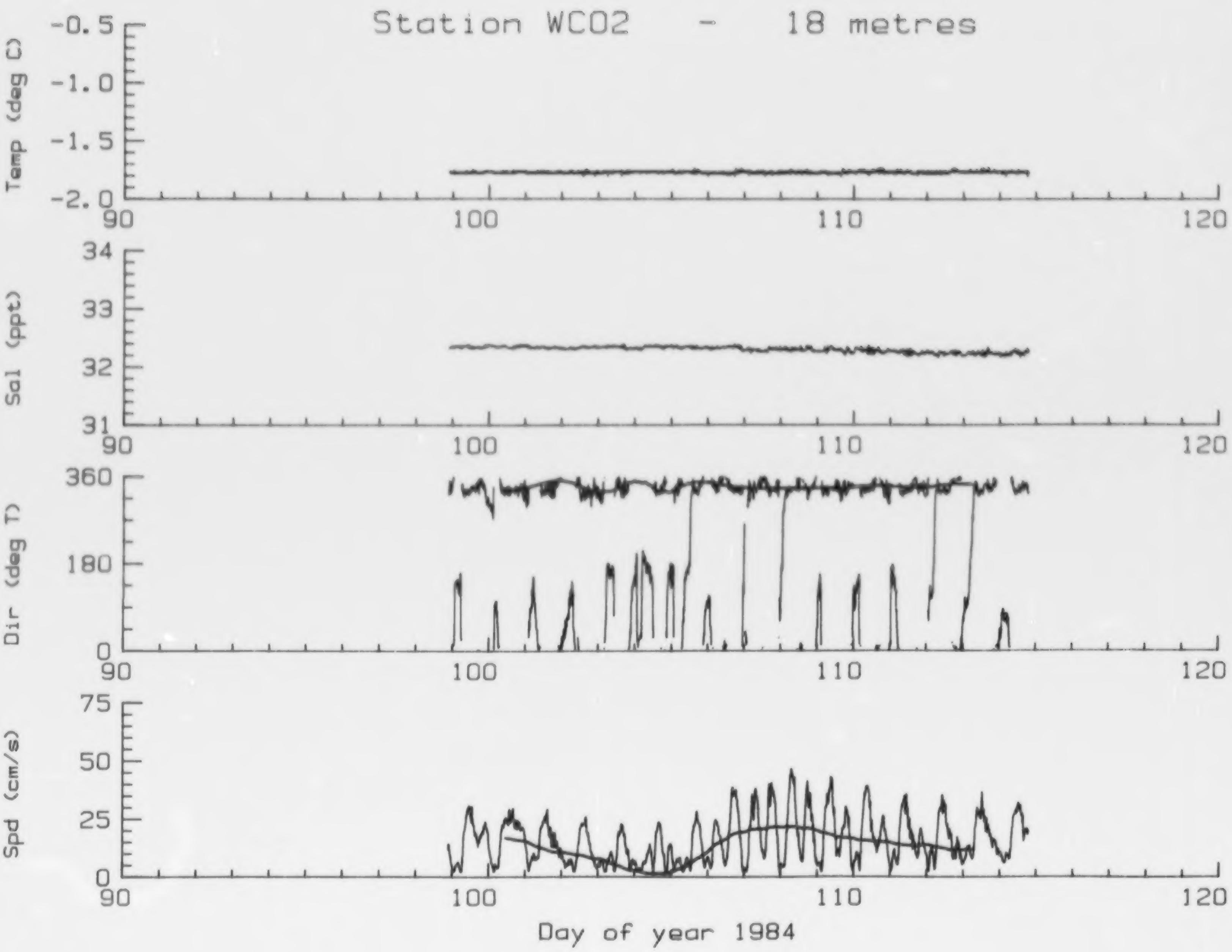
Day of year 1984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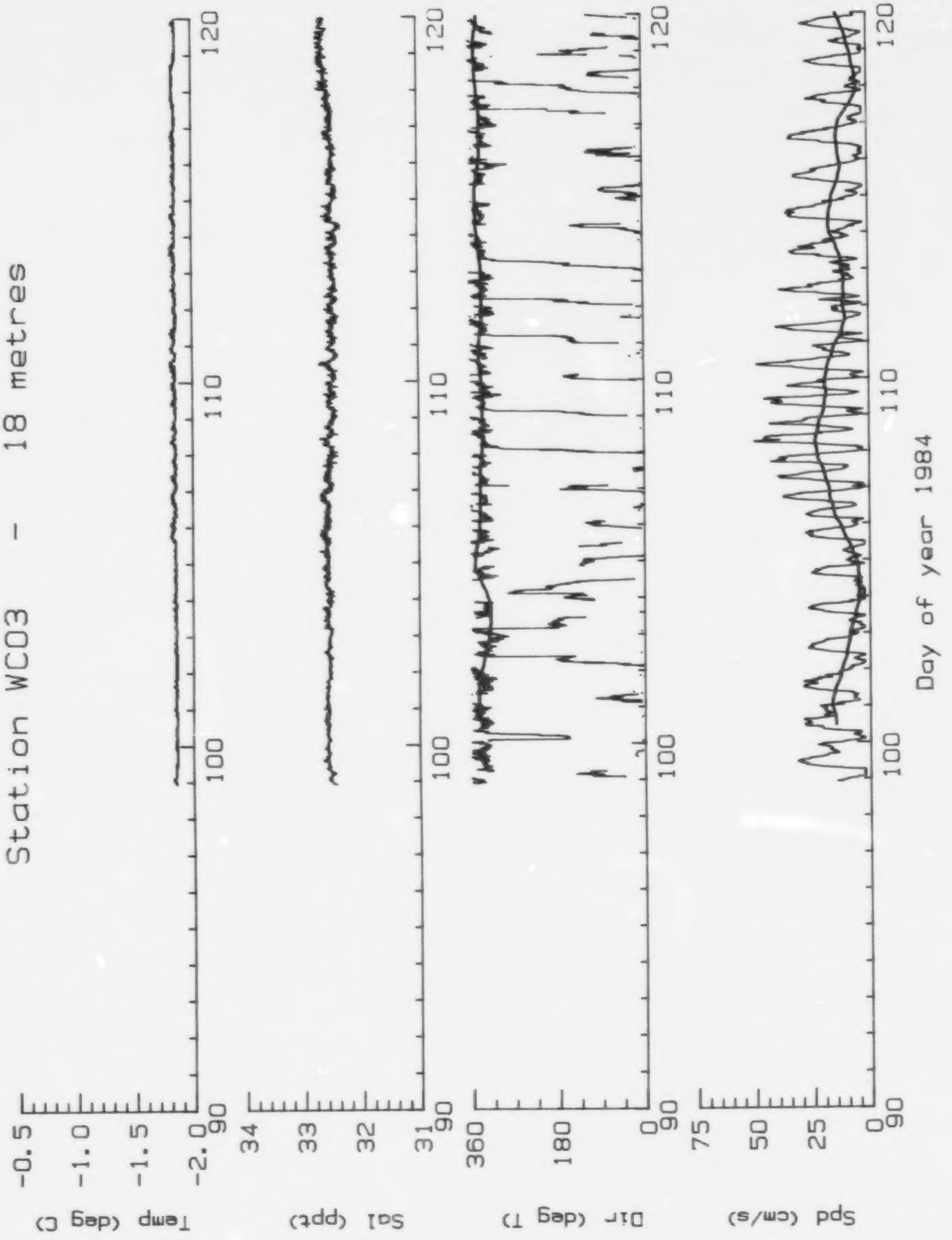
Day of year 1984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Spd (cm/s)
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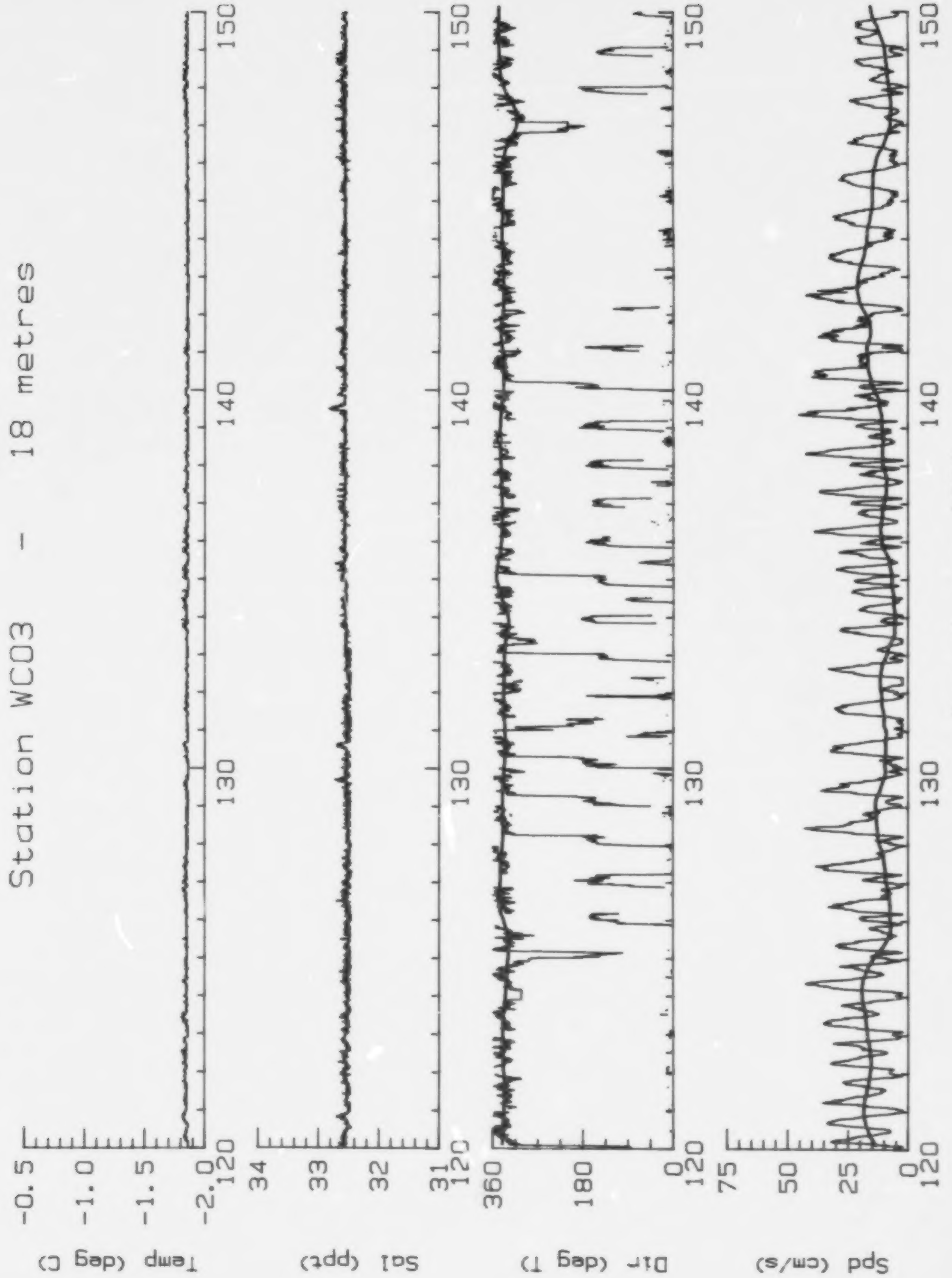
Day of year 1984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32
31
Dir (deg T)
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0
Spd (cm/s)
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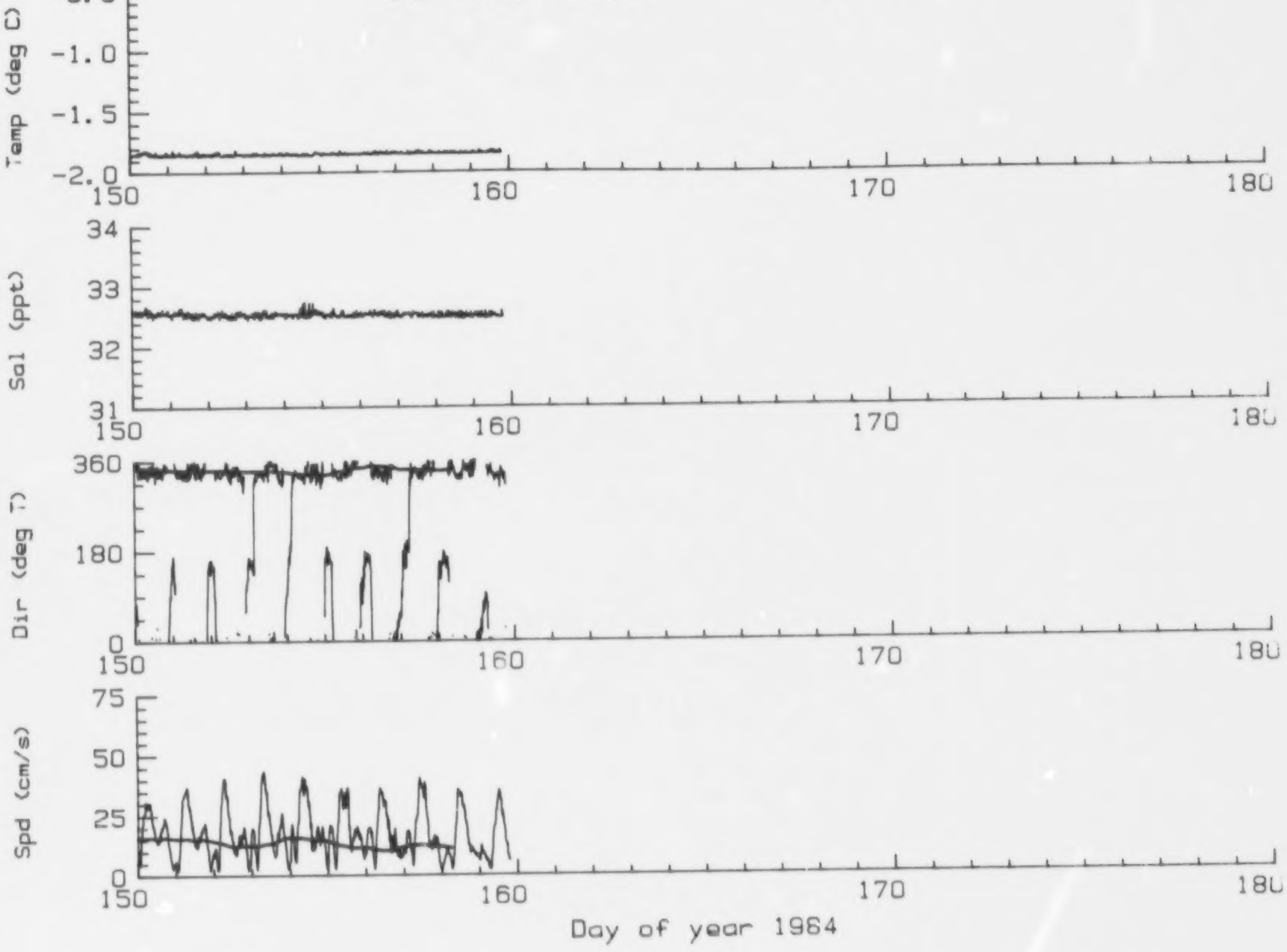
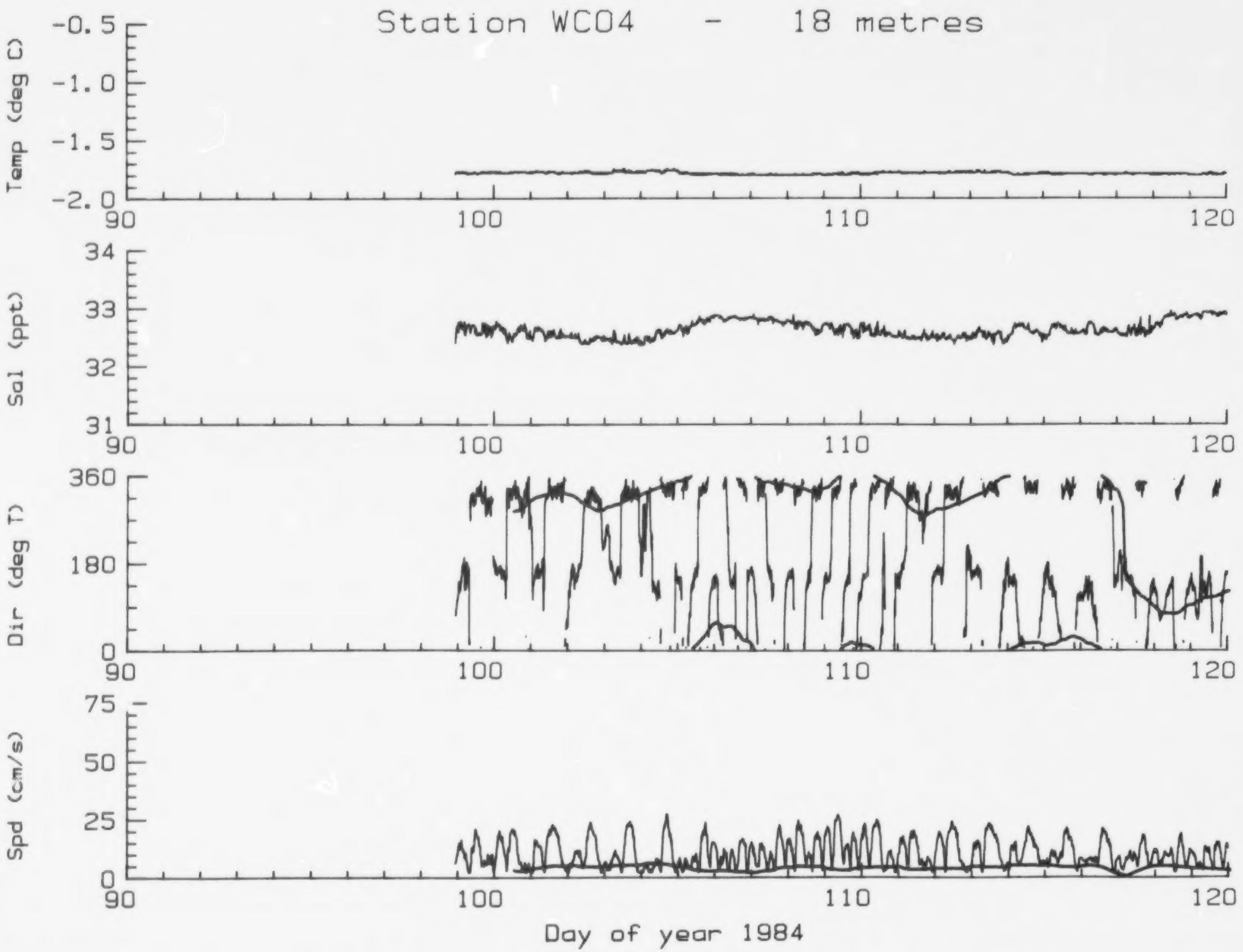
130
140
150
Day of year 1984

Station WC03 - 18 metres

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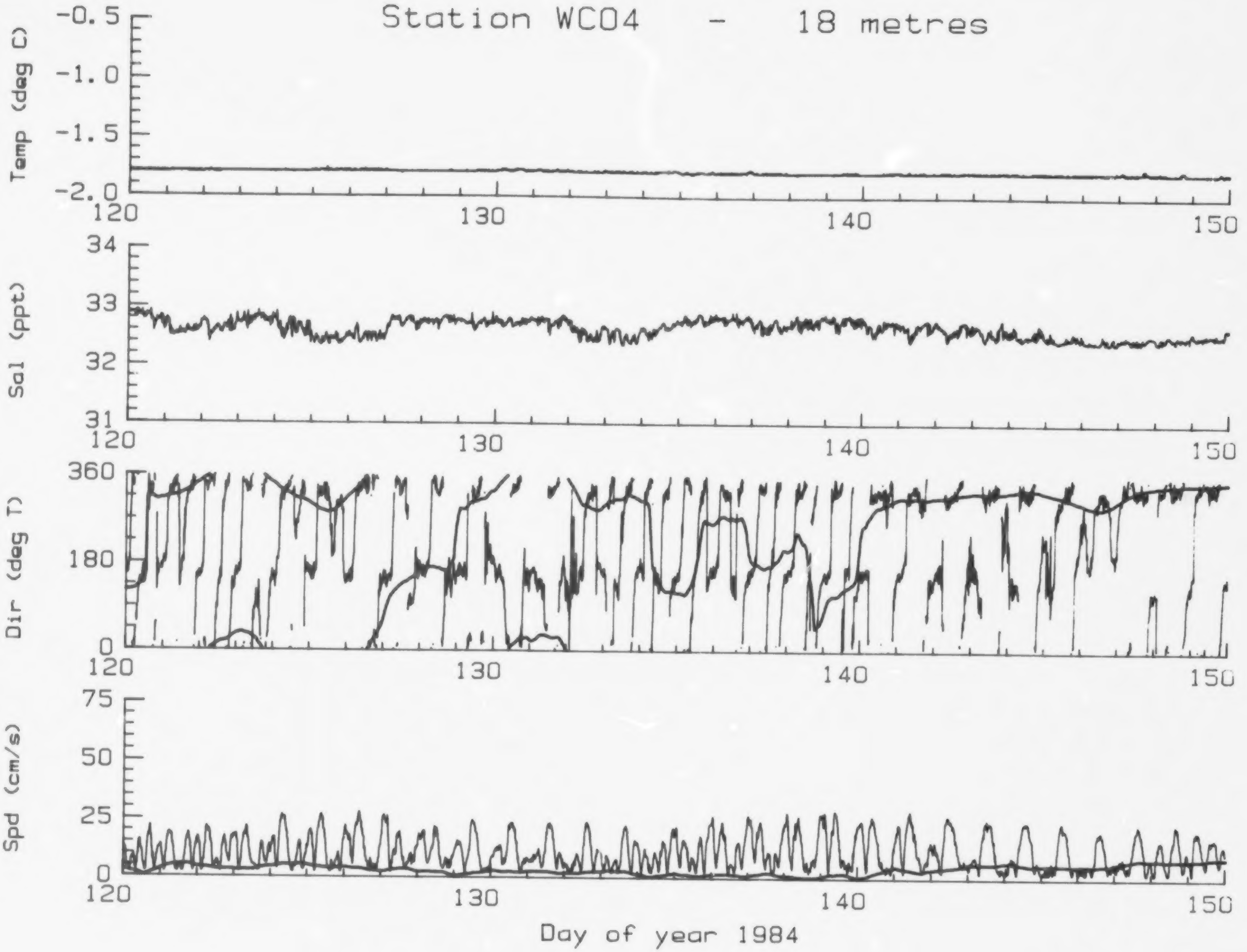
Day of year 1984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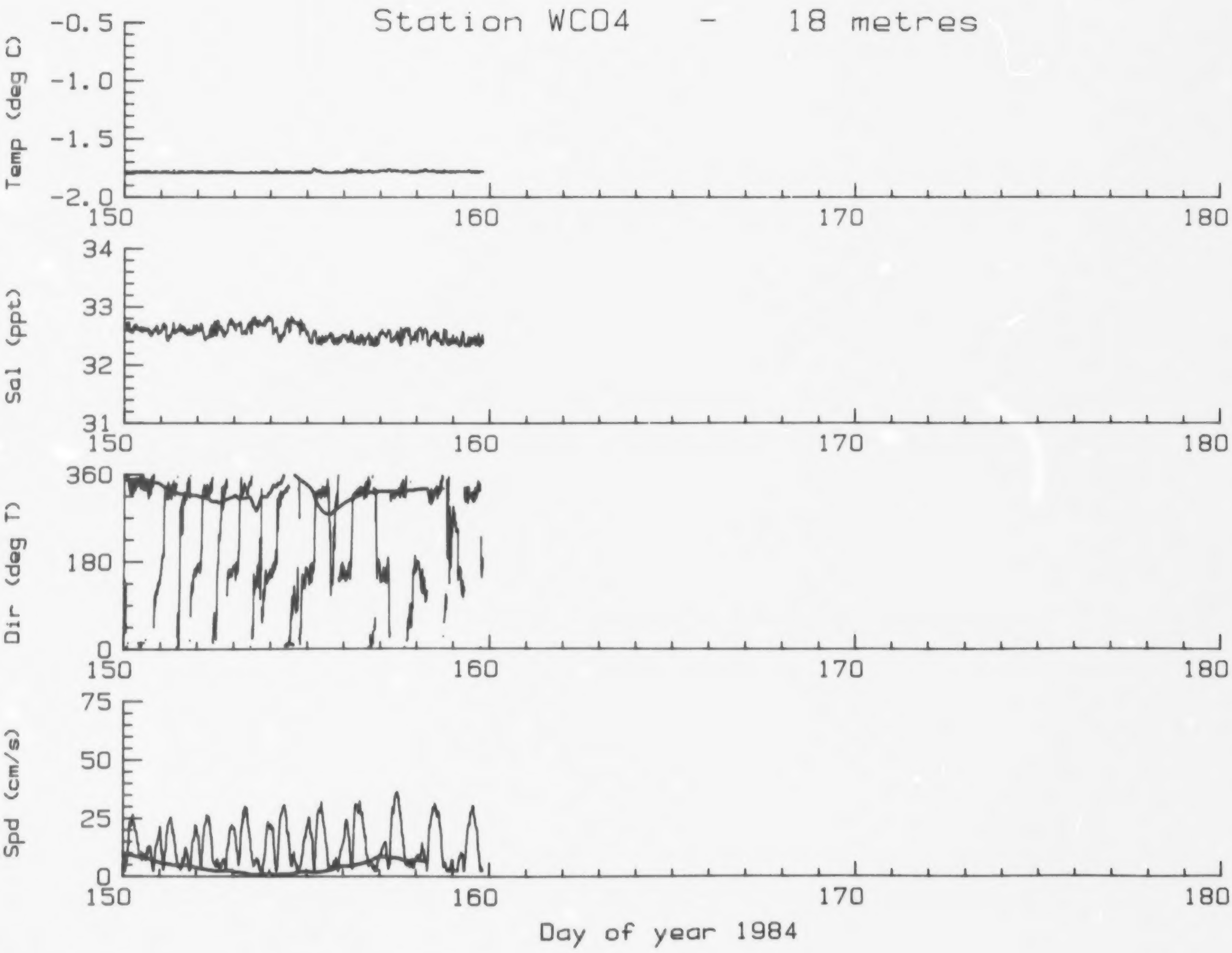
Day of year 1984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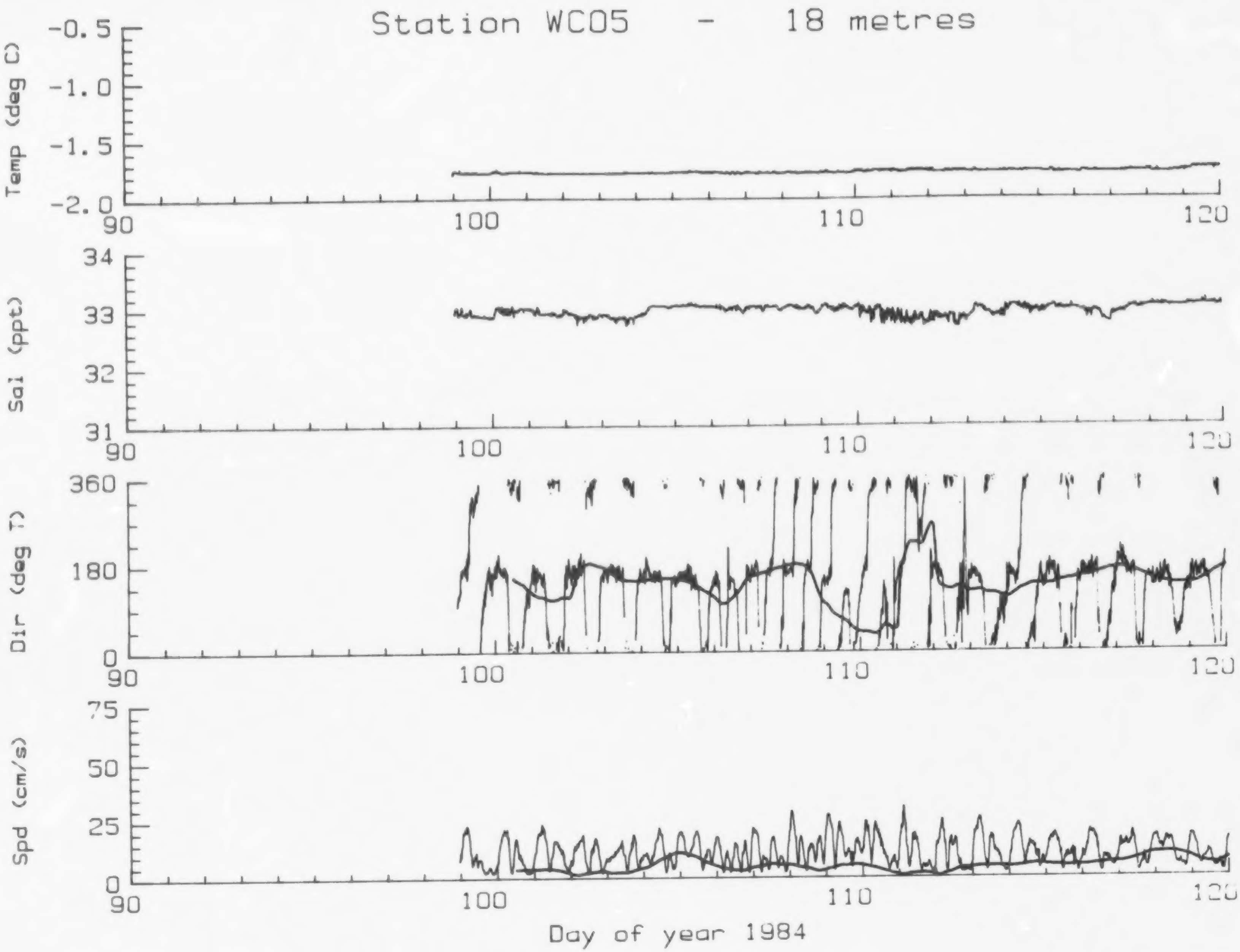
Day of year 1984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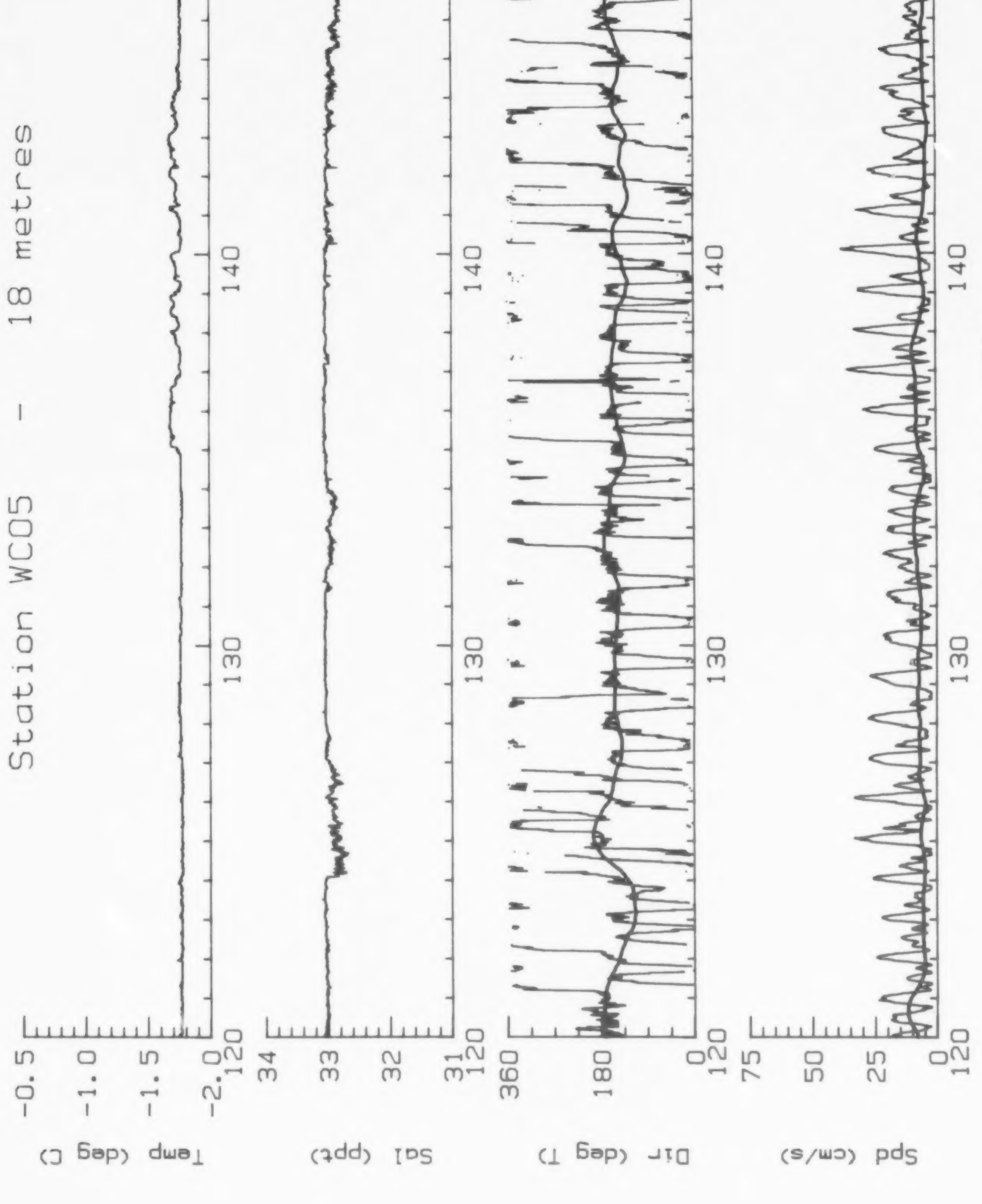
Day of year 1984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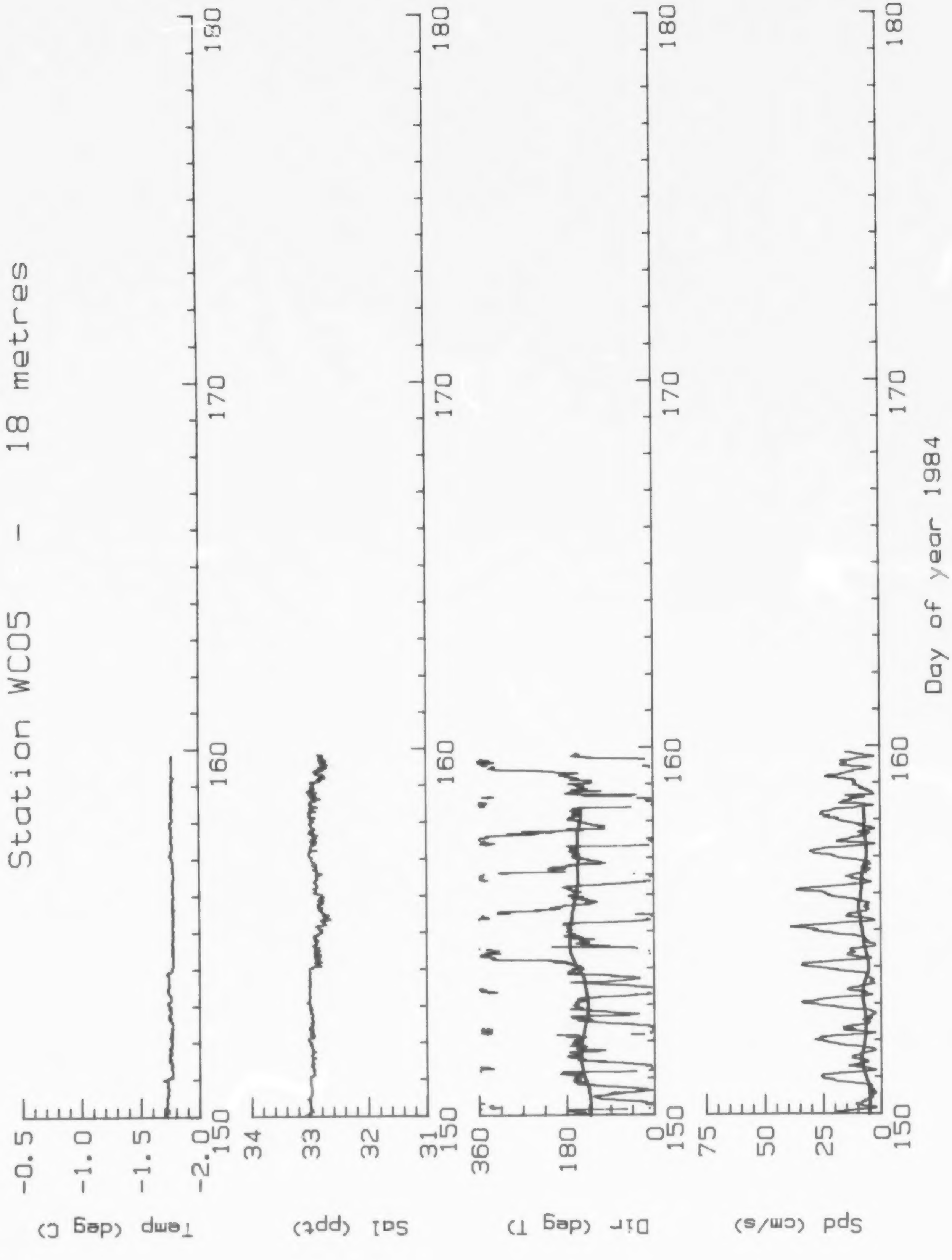
Day of year 1984



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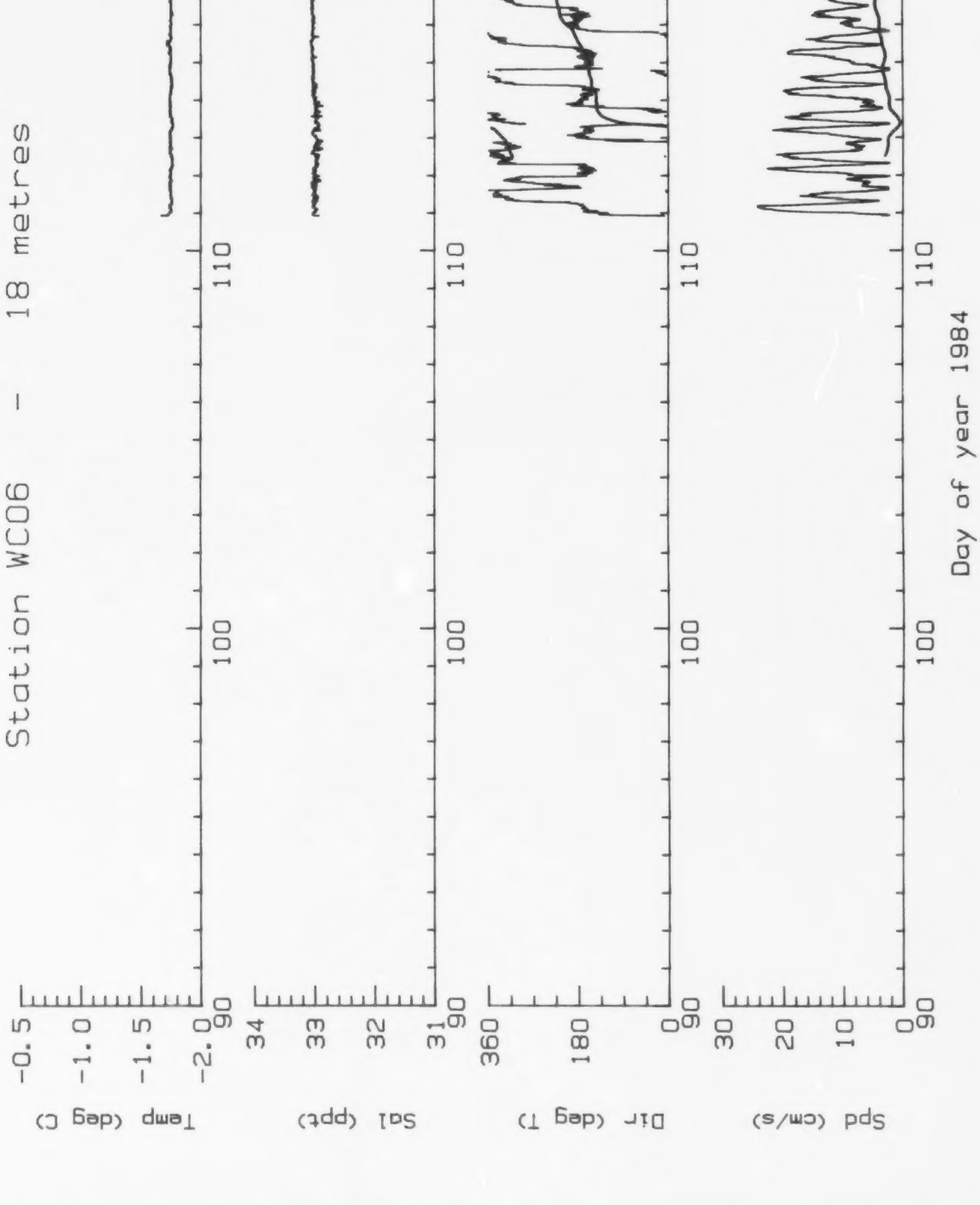
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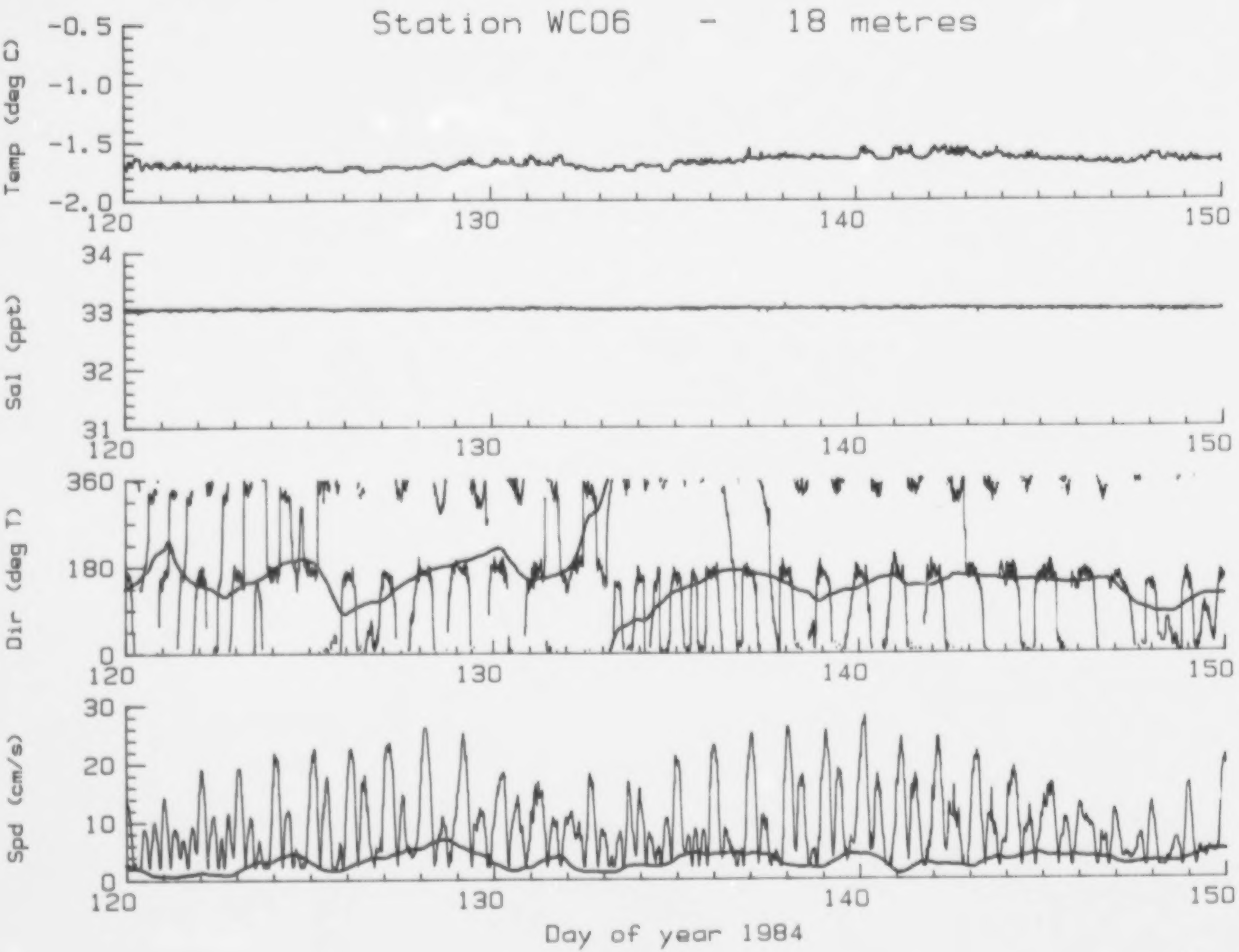
Day of year 1984



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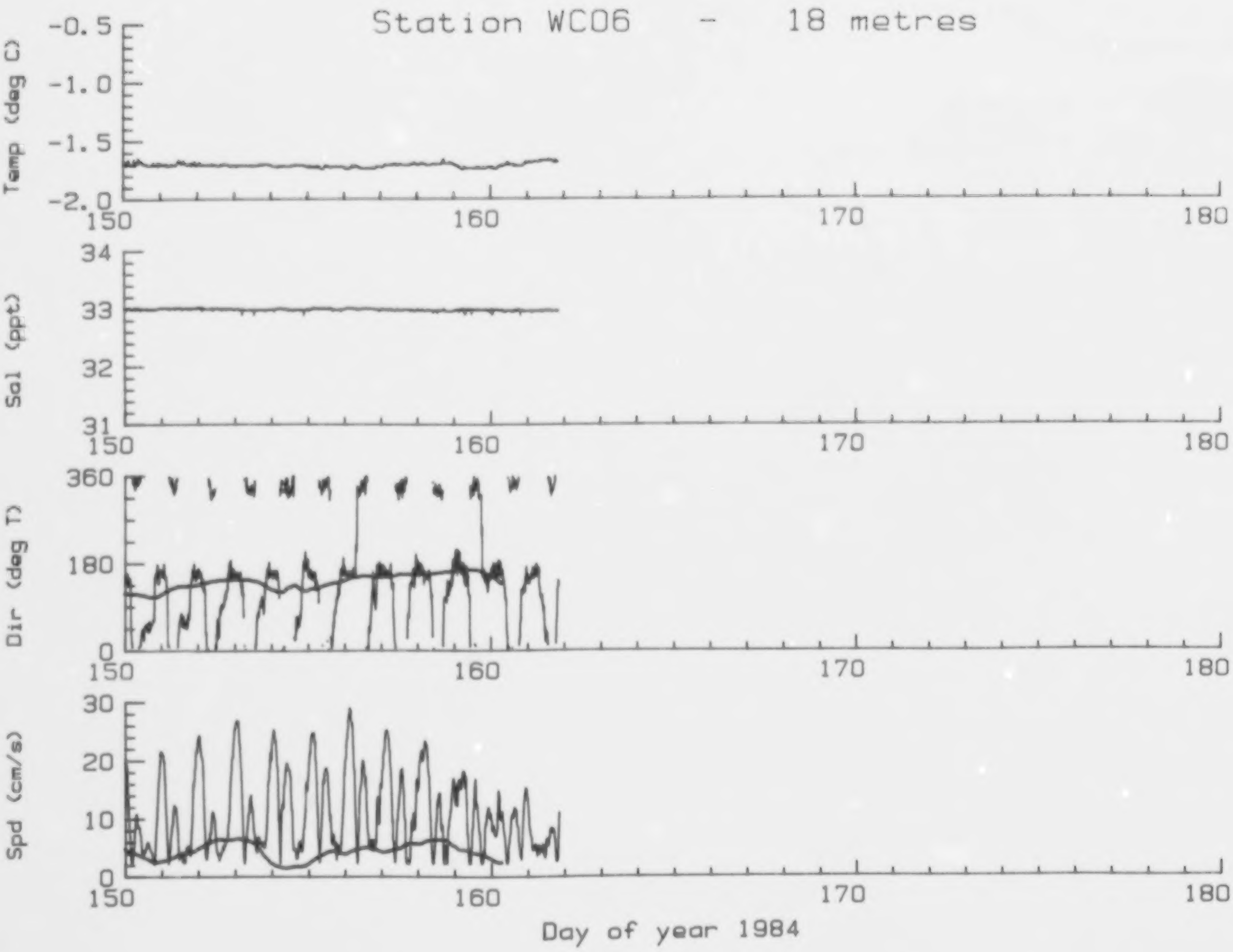
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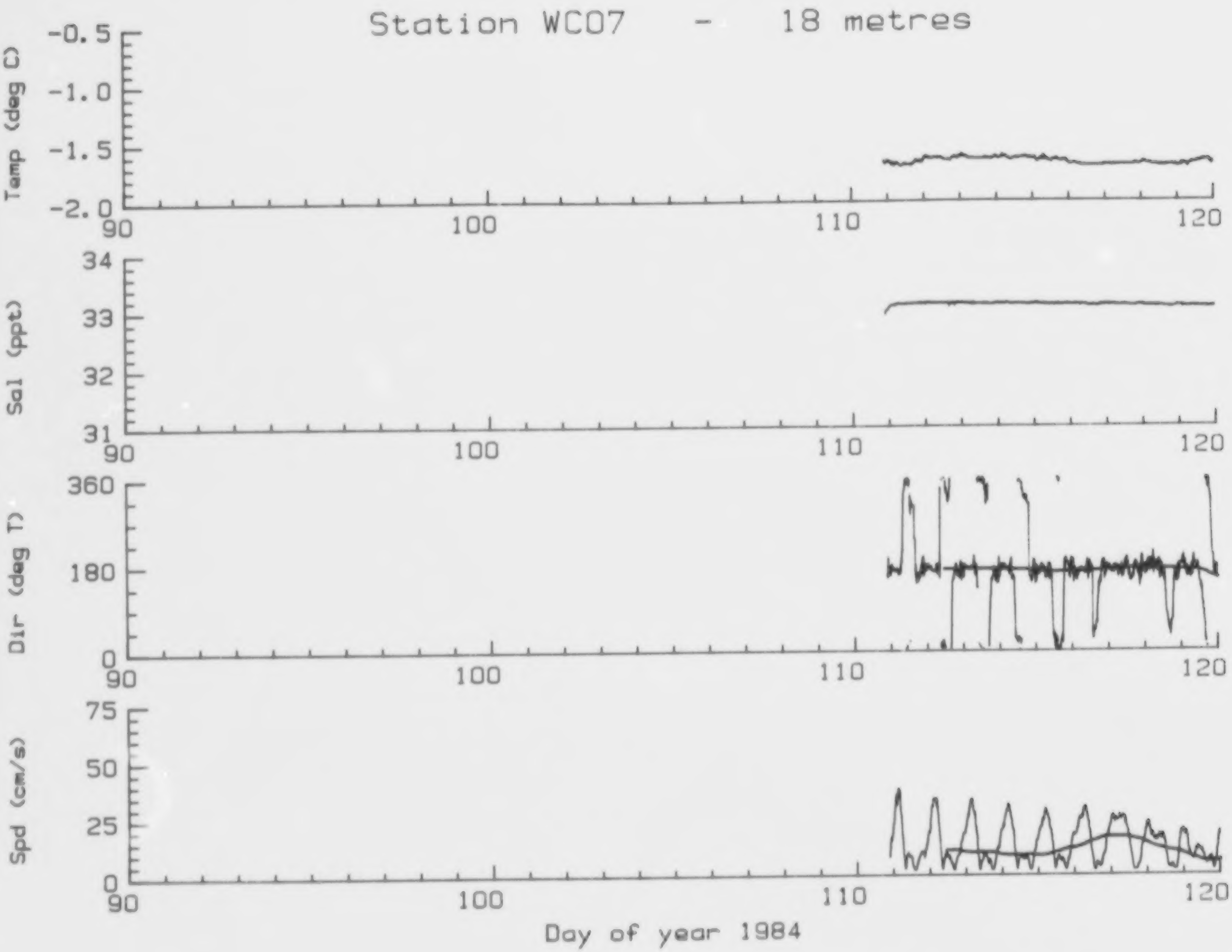
Day of year 1984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Spd (cm/s)
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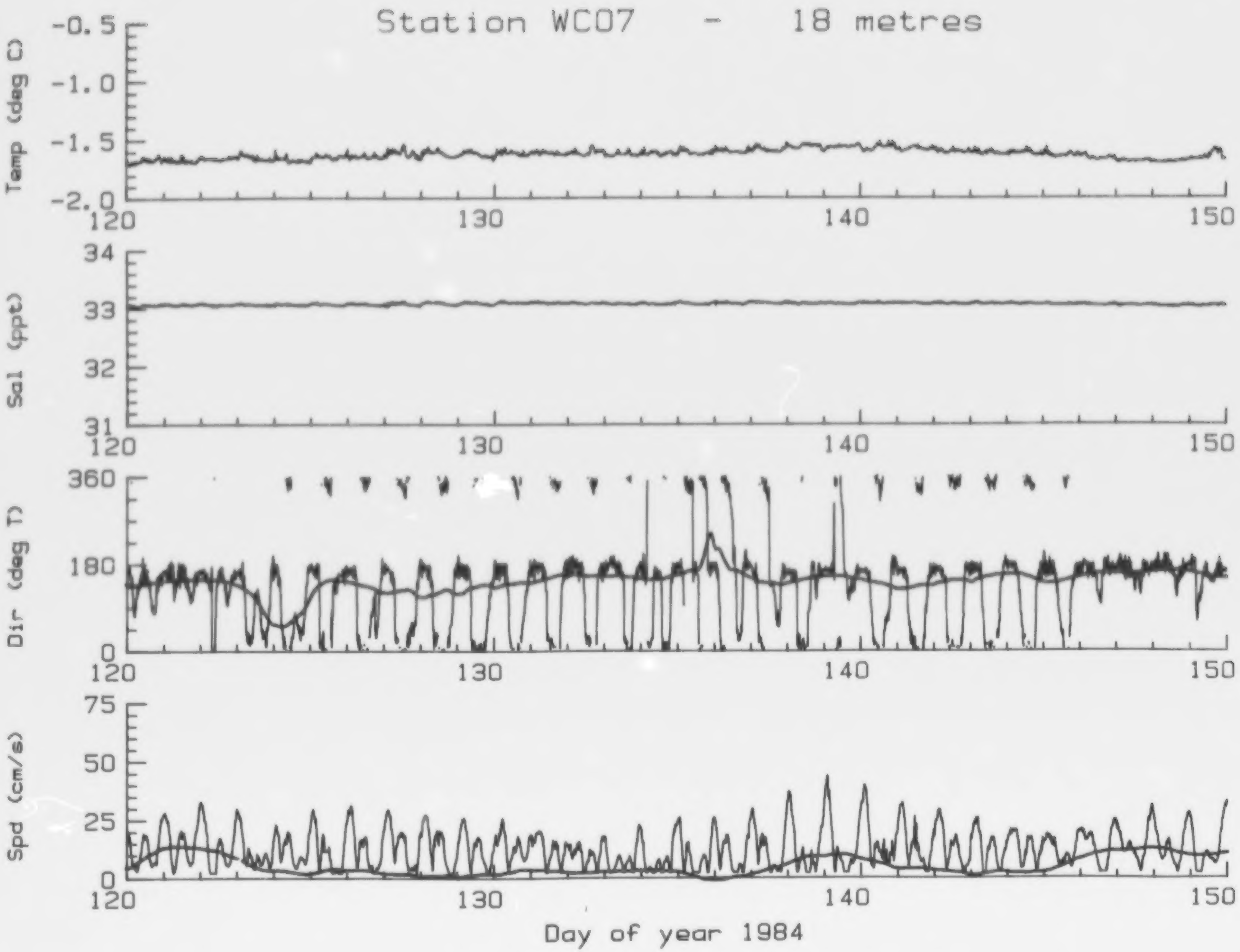
Day of year 1984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Dir (deg T)
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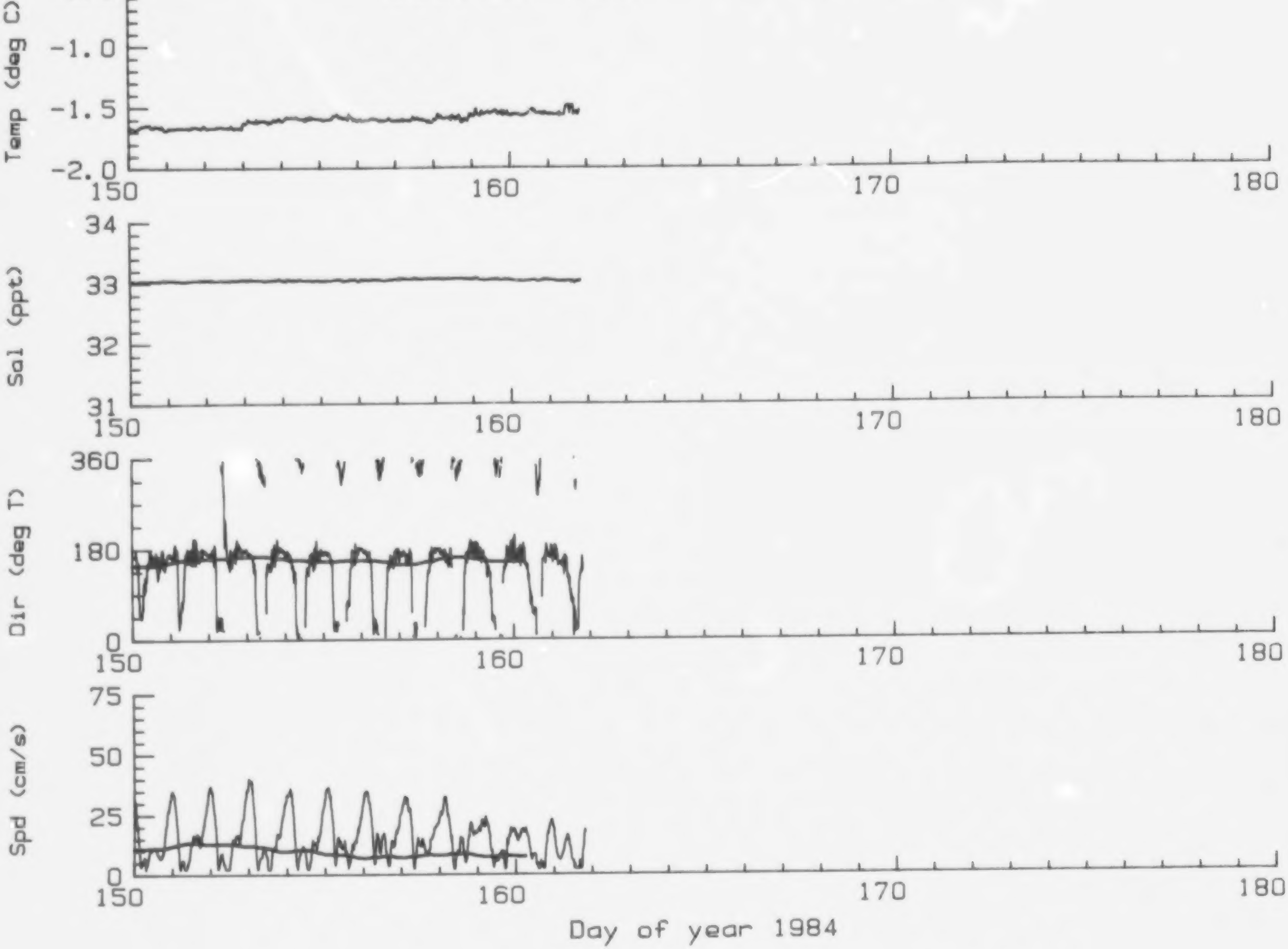
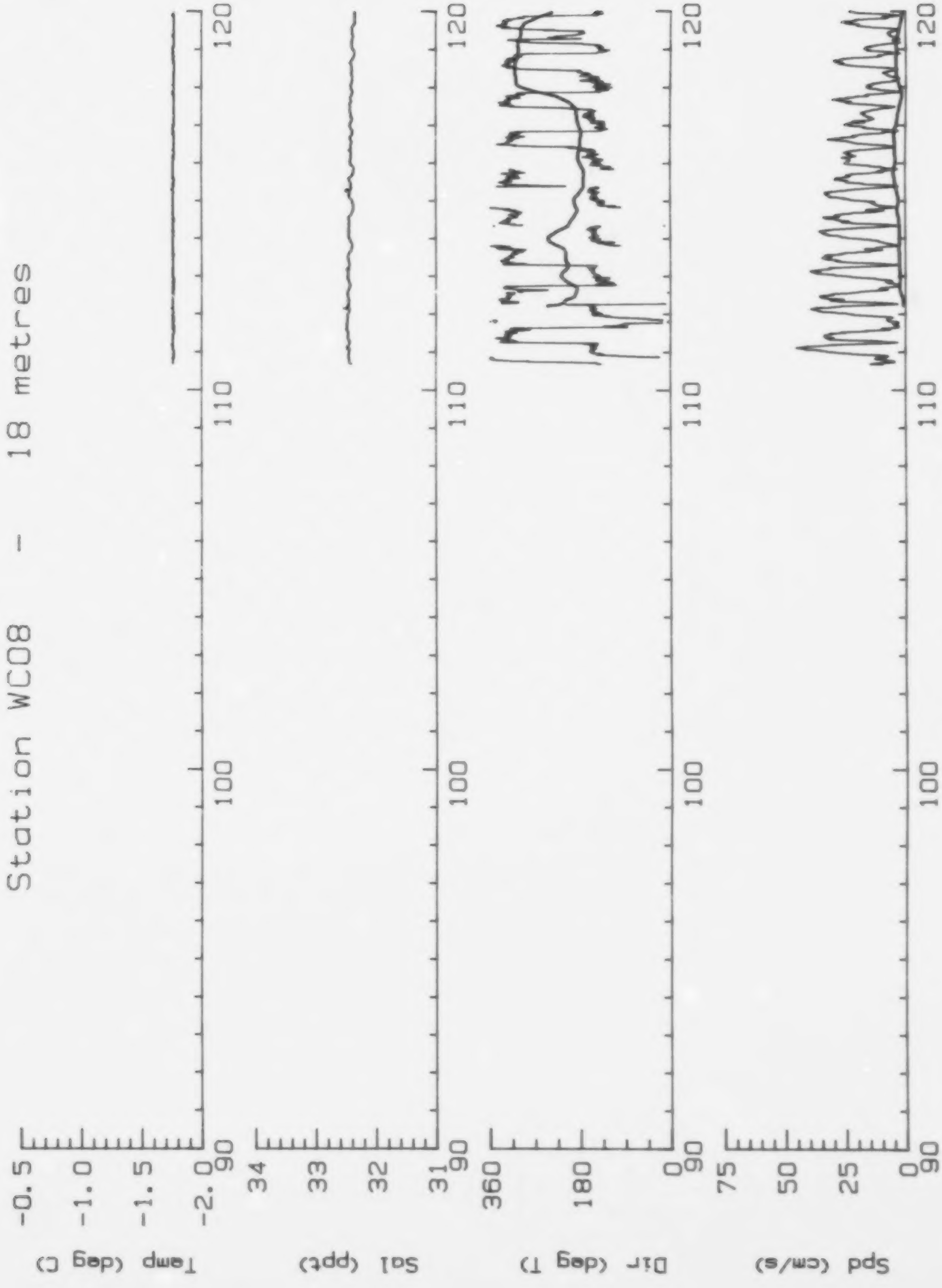
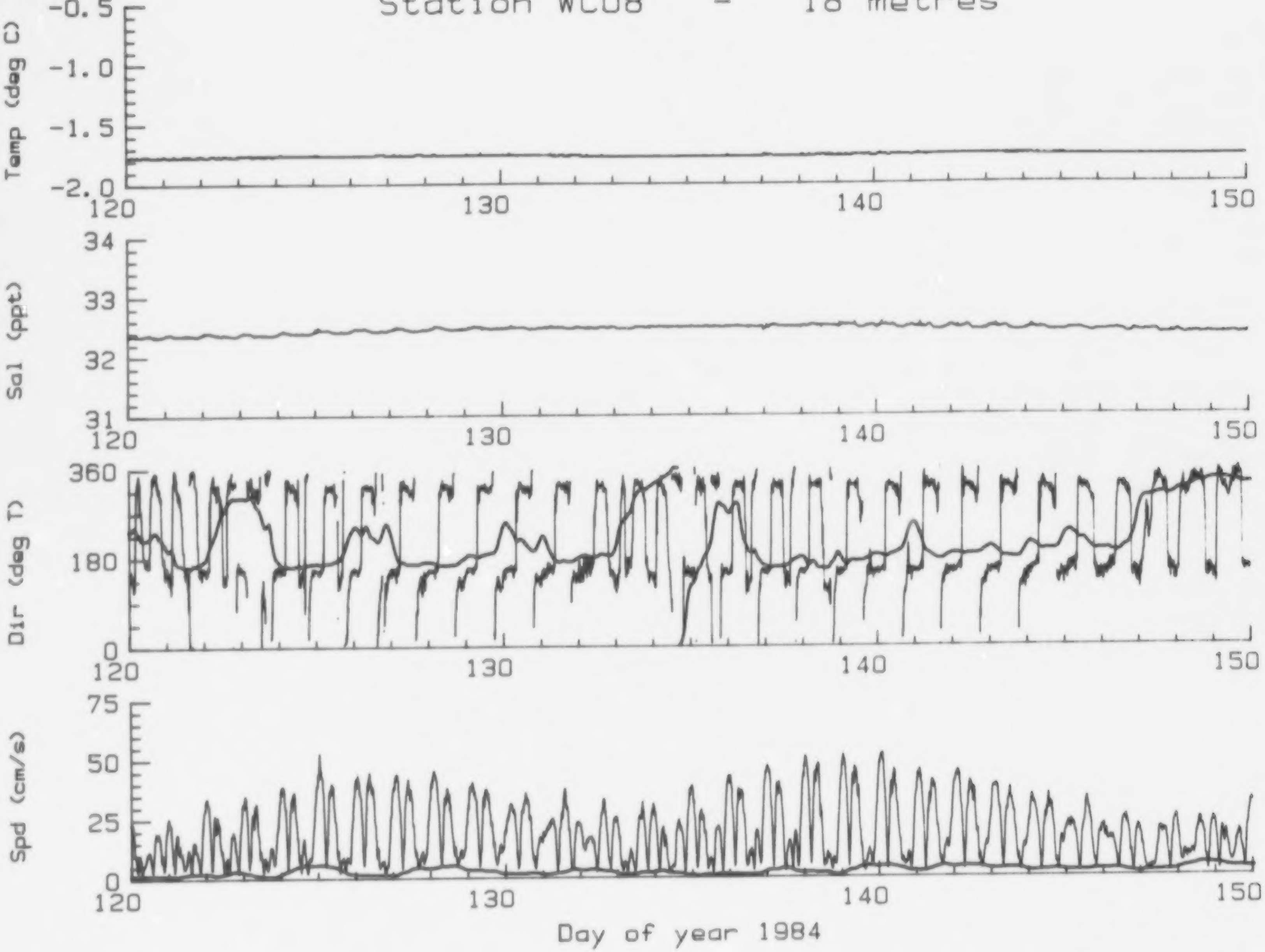
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984

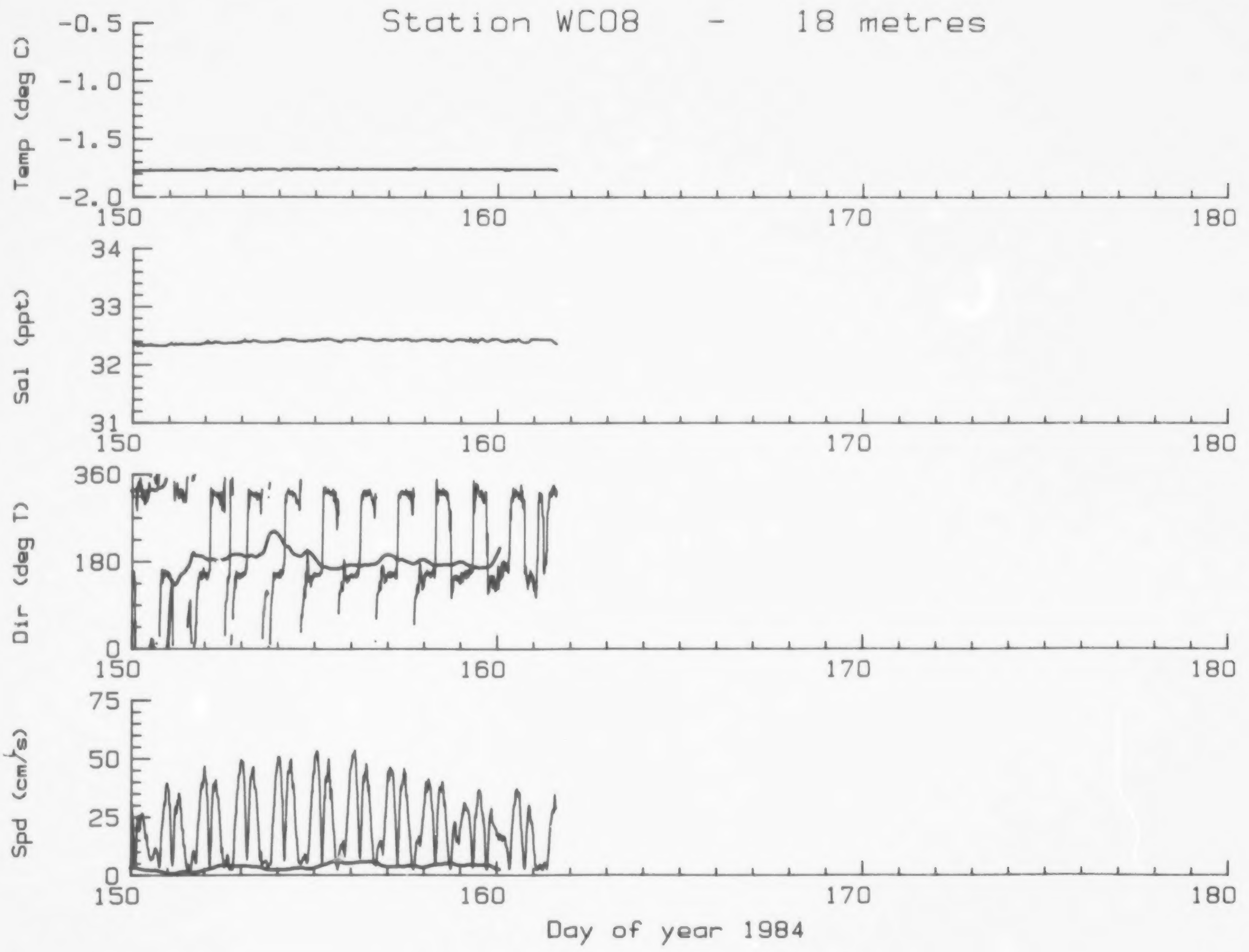
Station WC07 - 18 metres

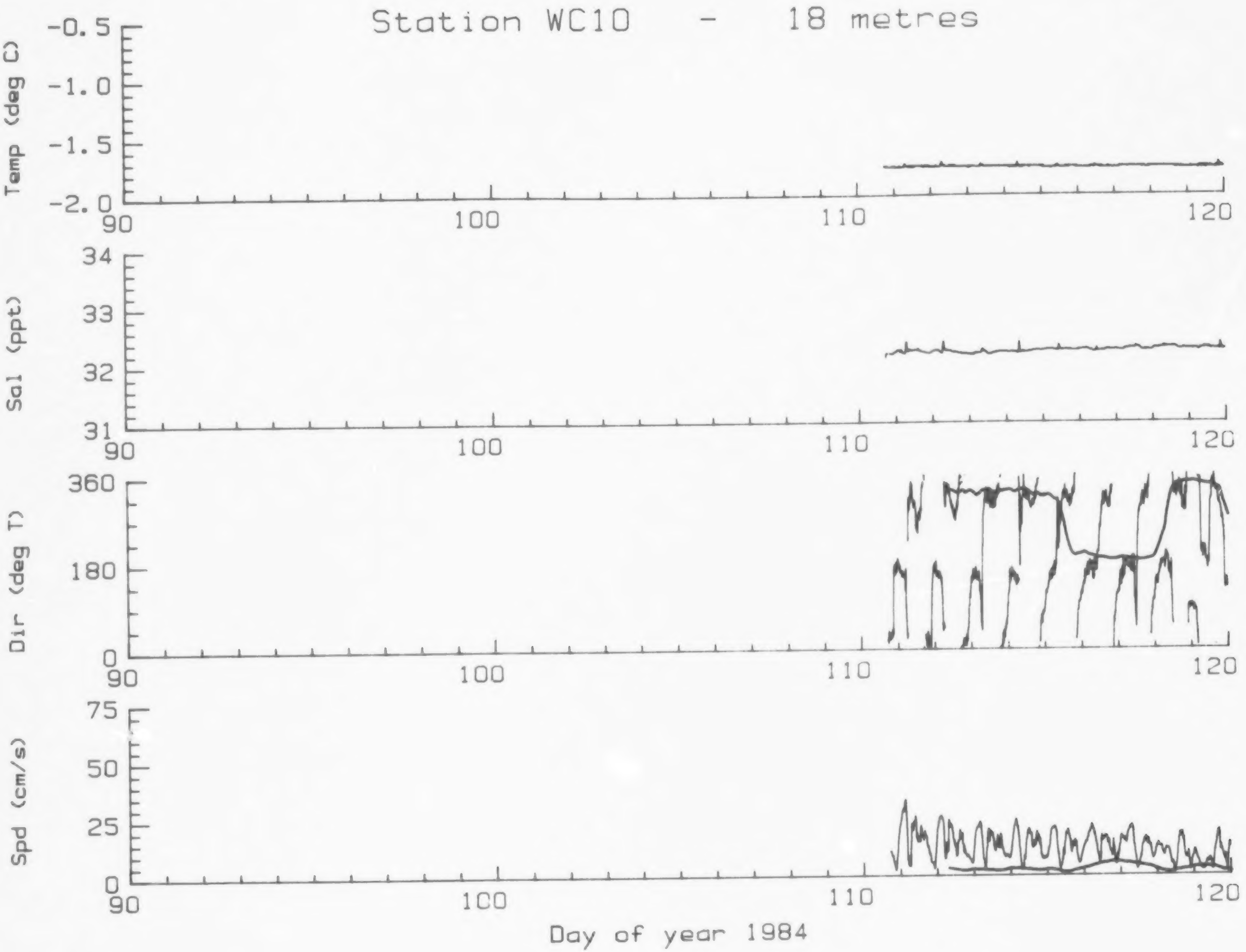


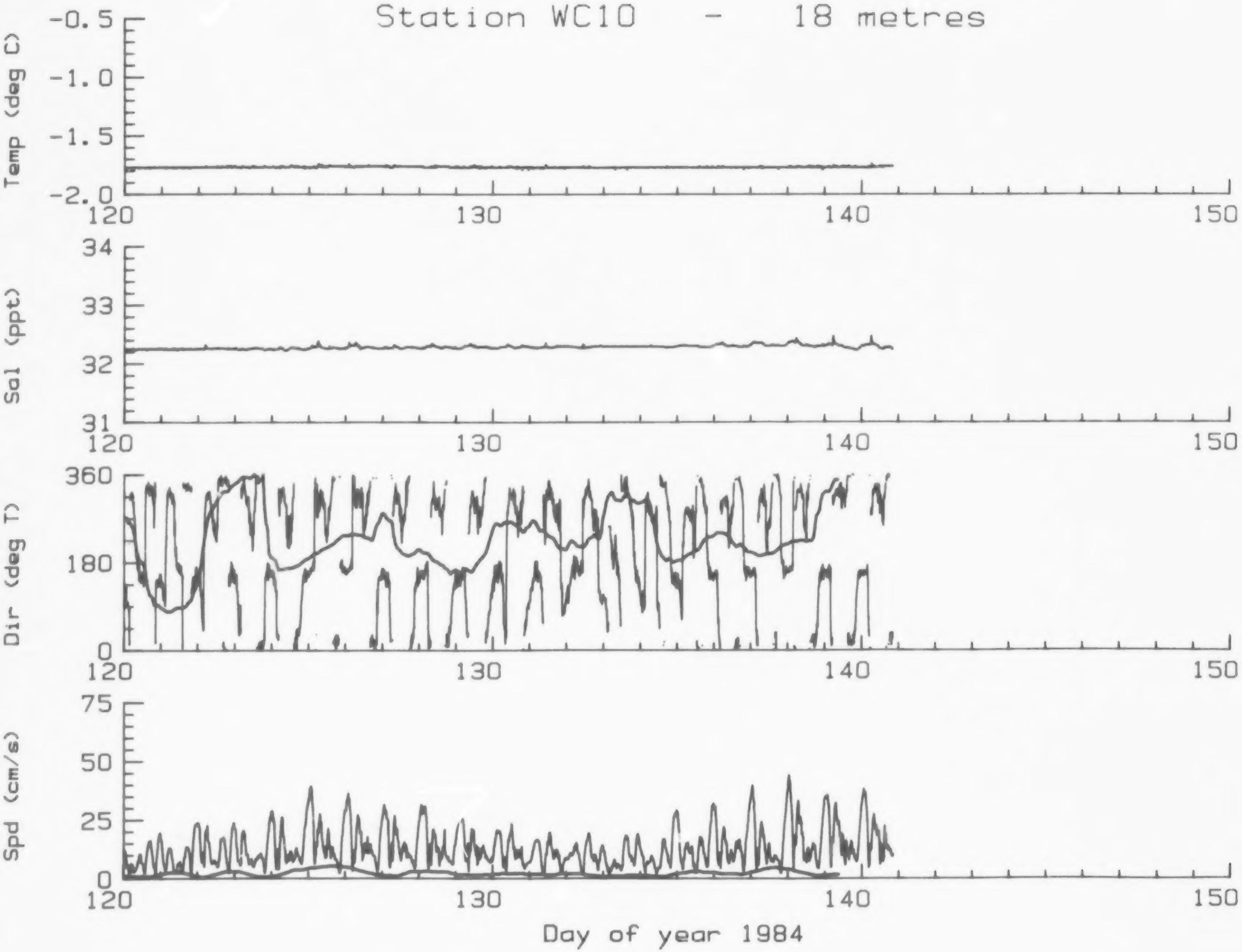

Station WC08 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984

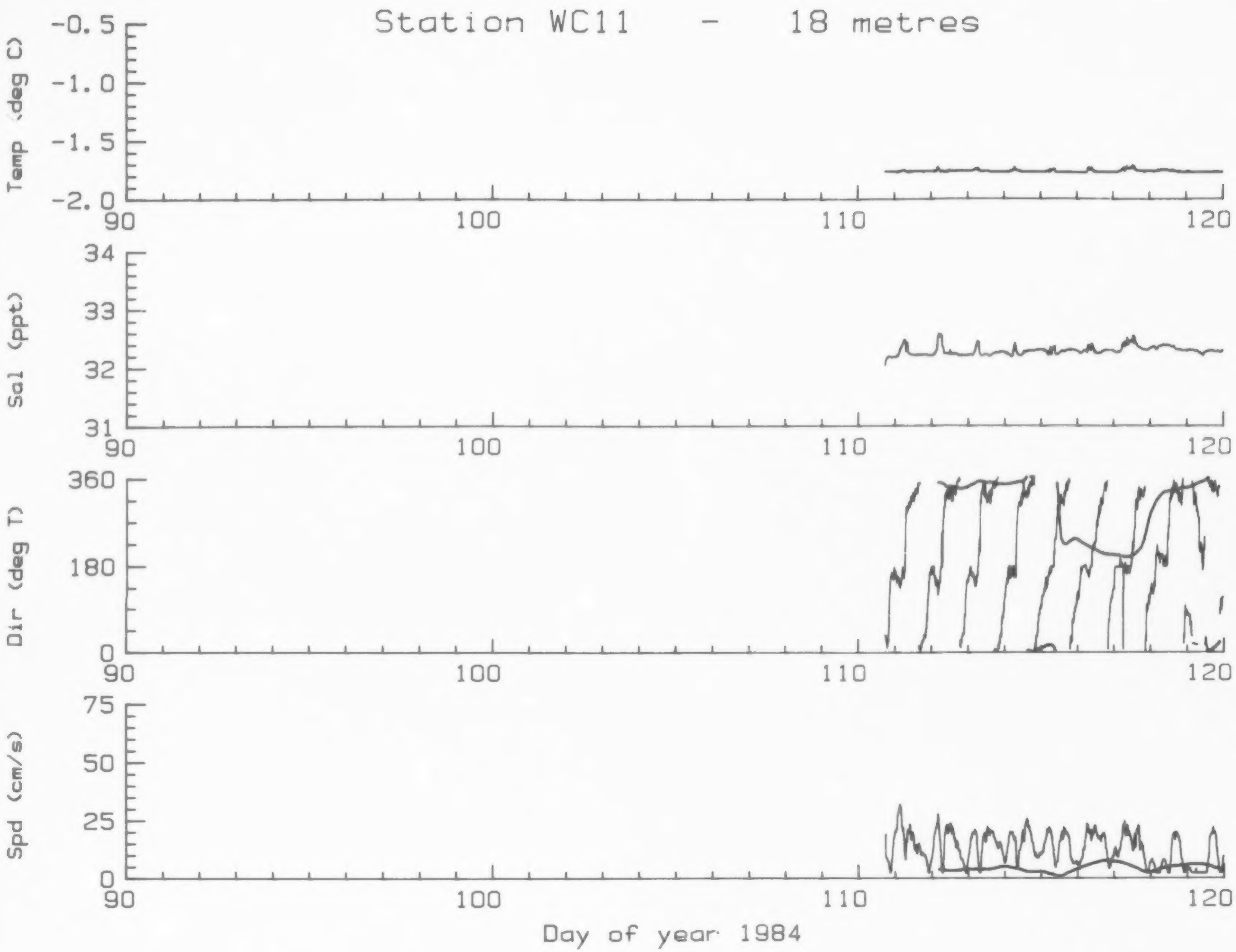


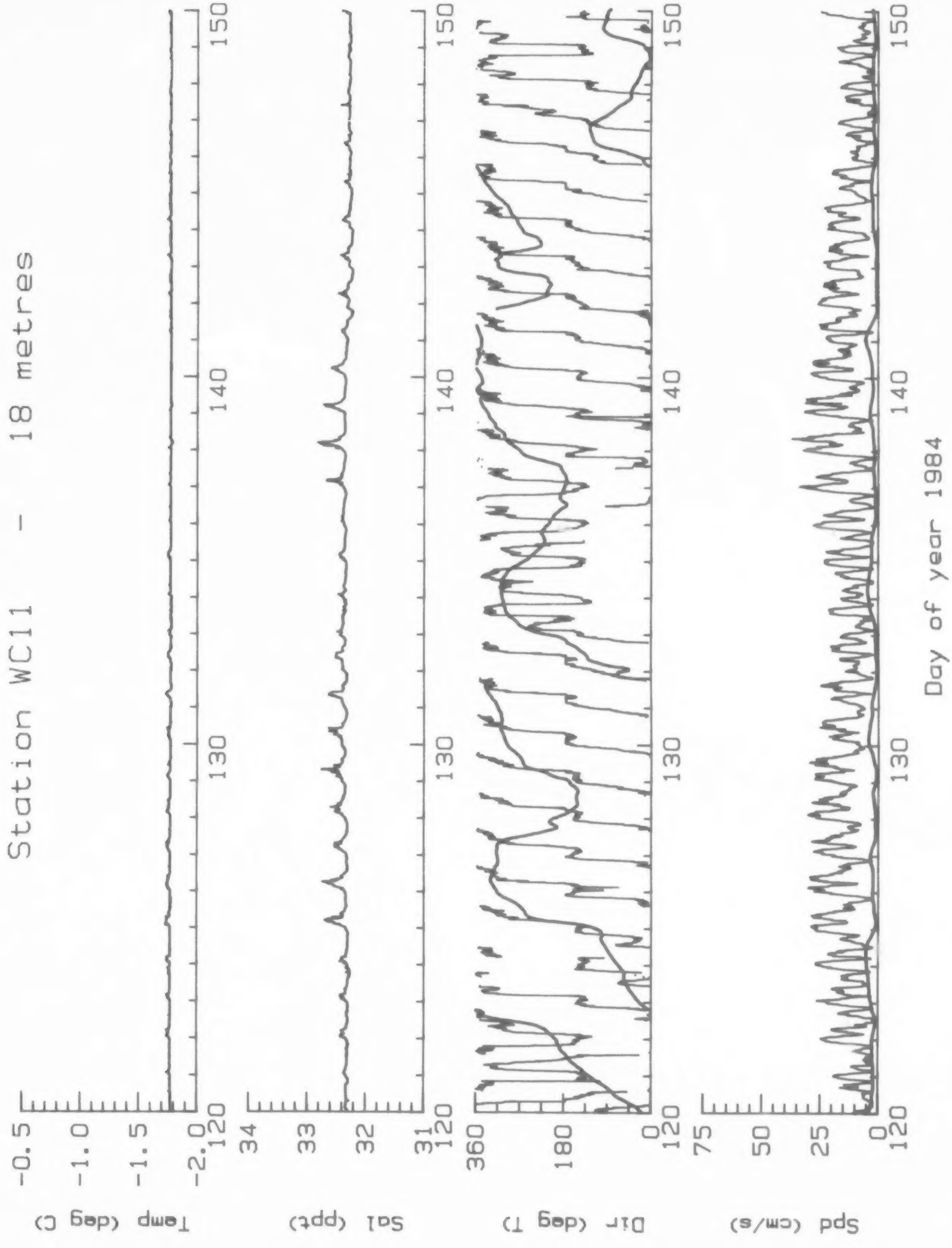
Station WC08 - 18 metres

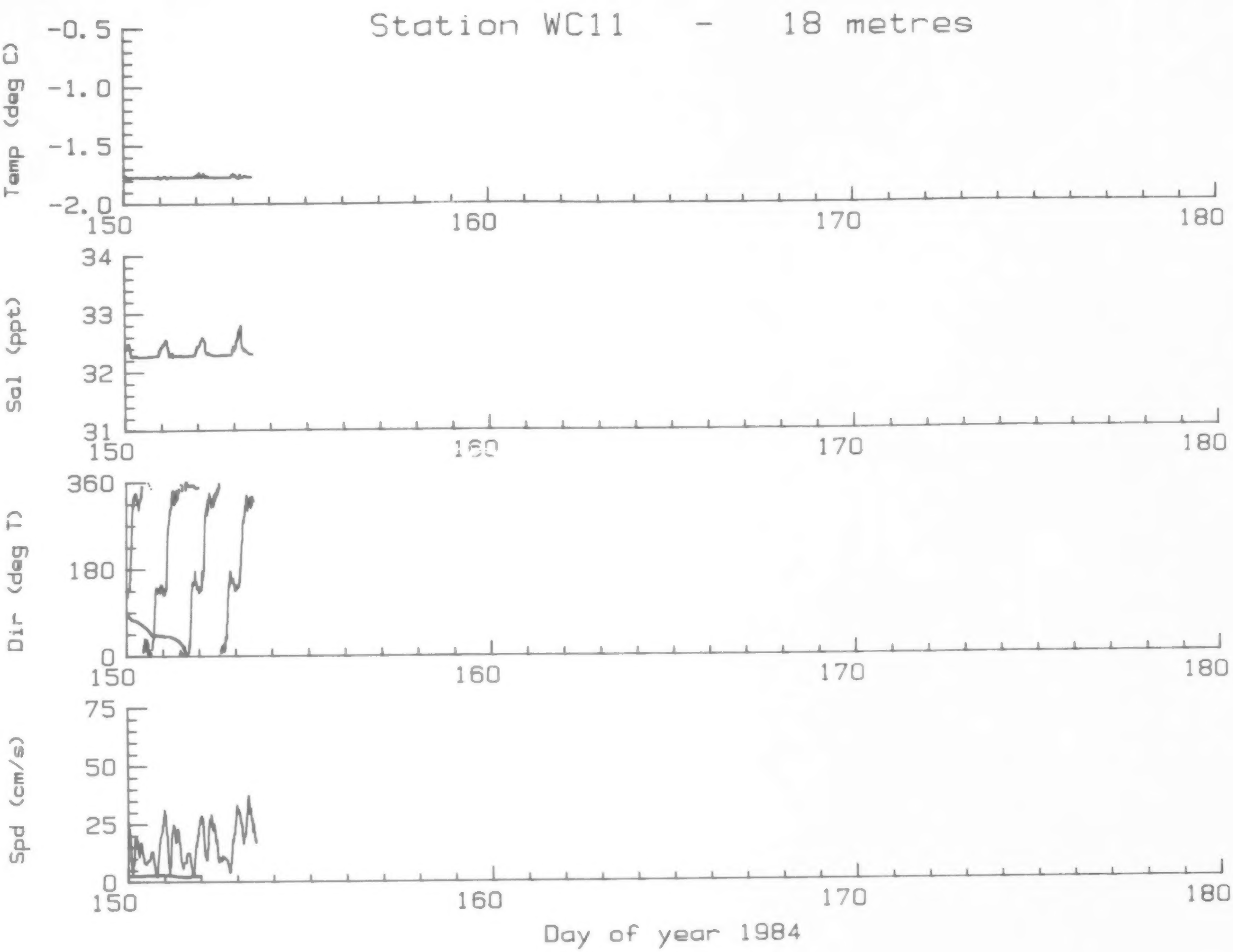

Station WC08 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

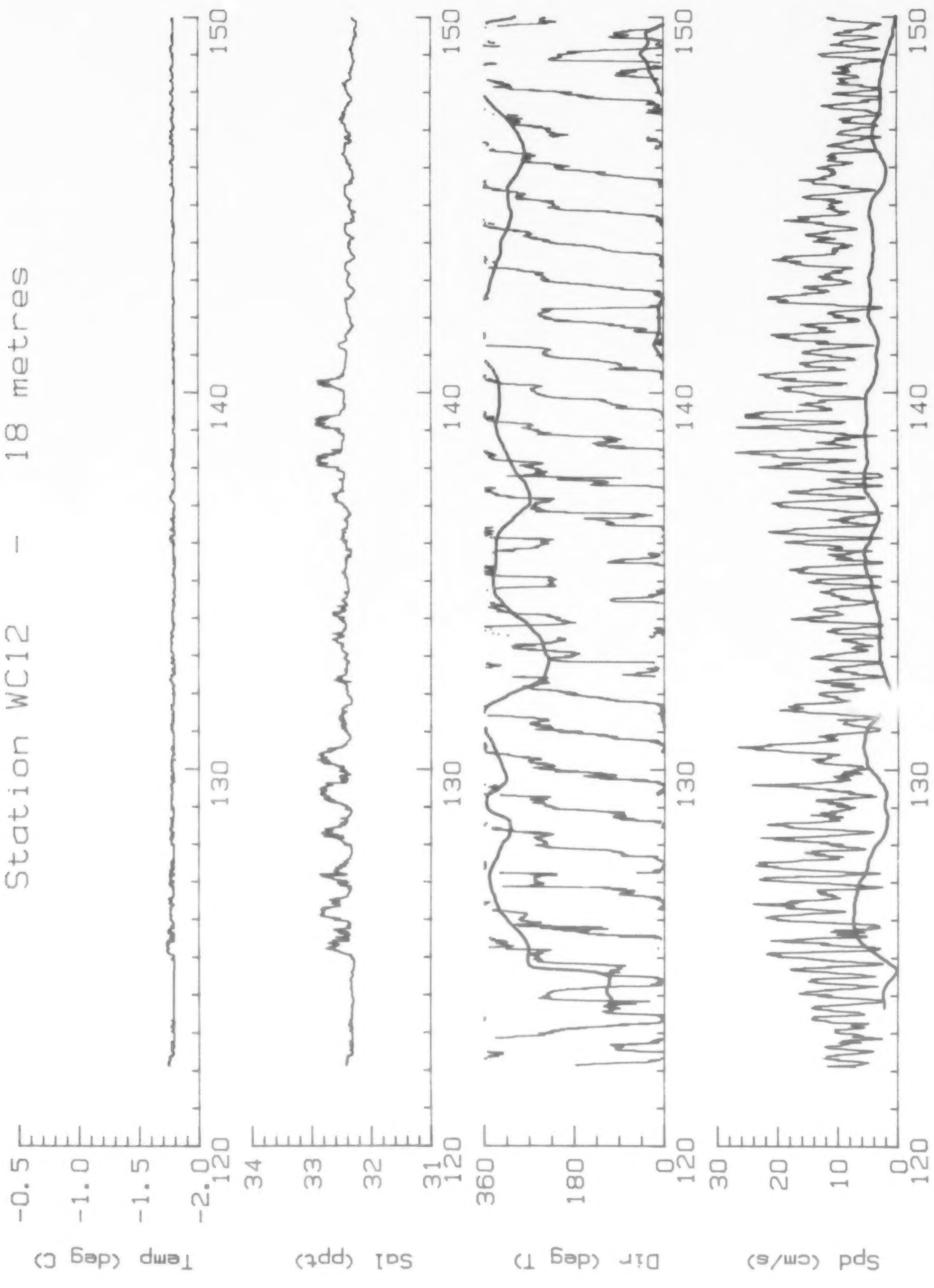

Station WC10 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984

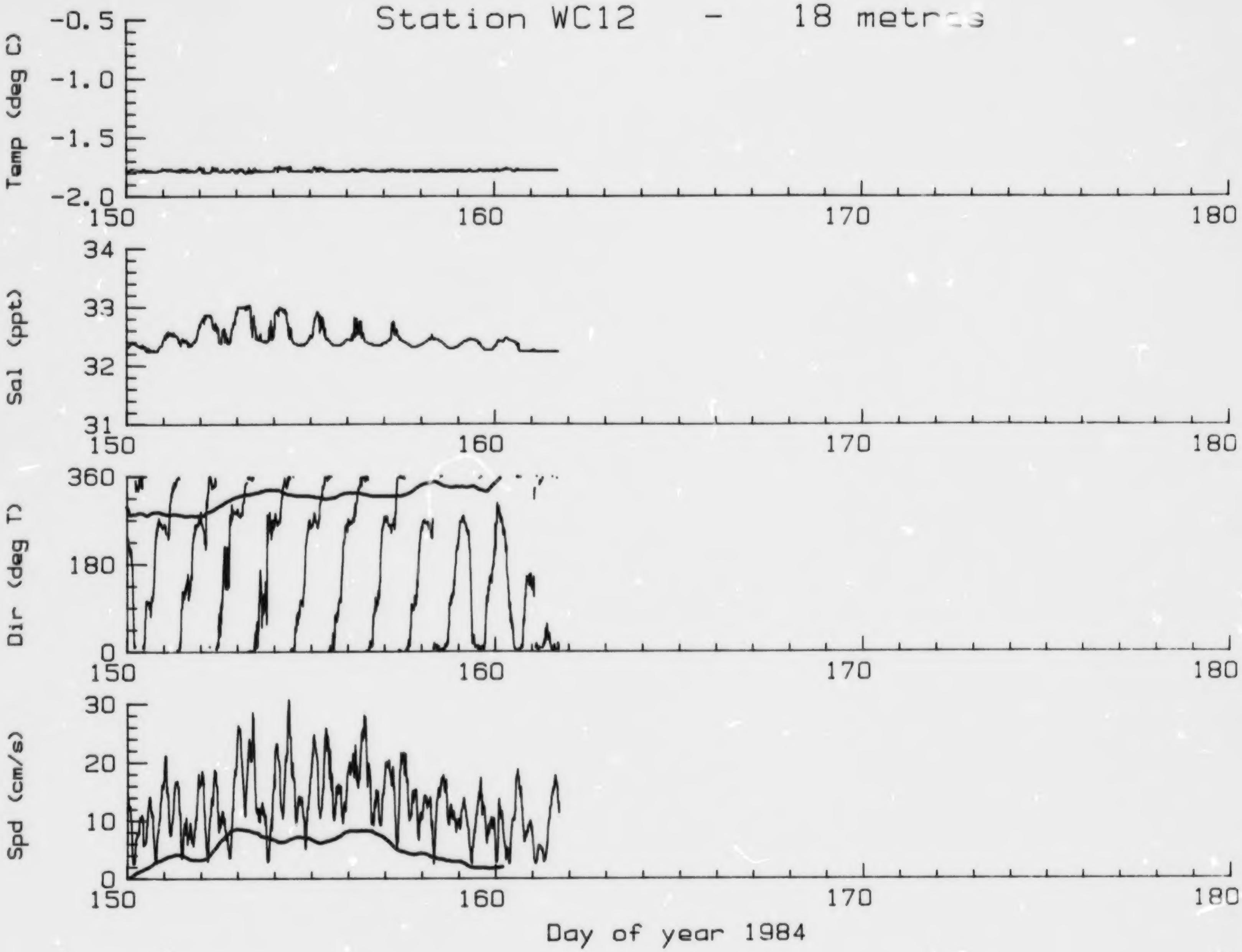

Station WC10 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984

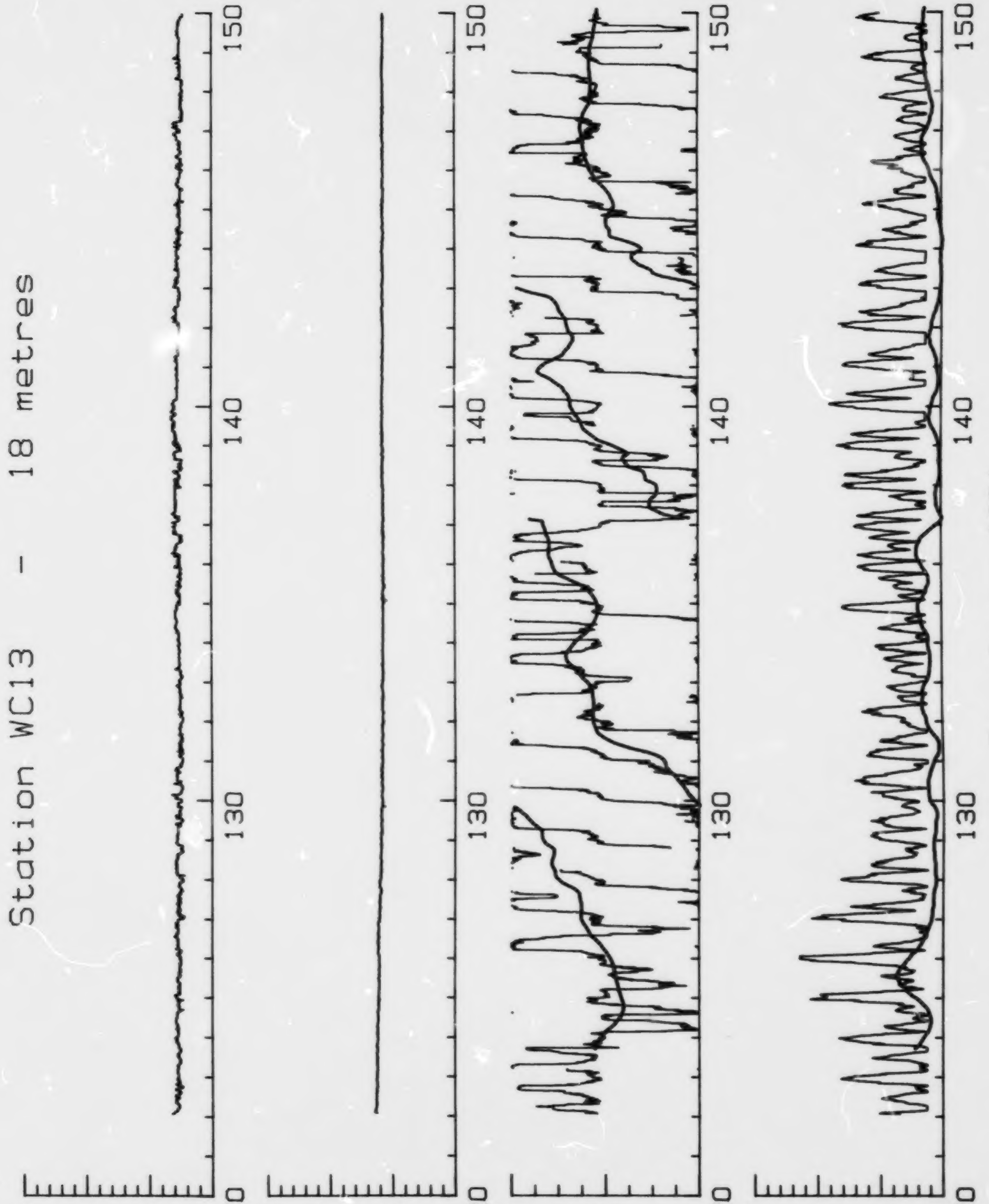

Station WC11 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984

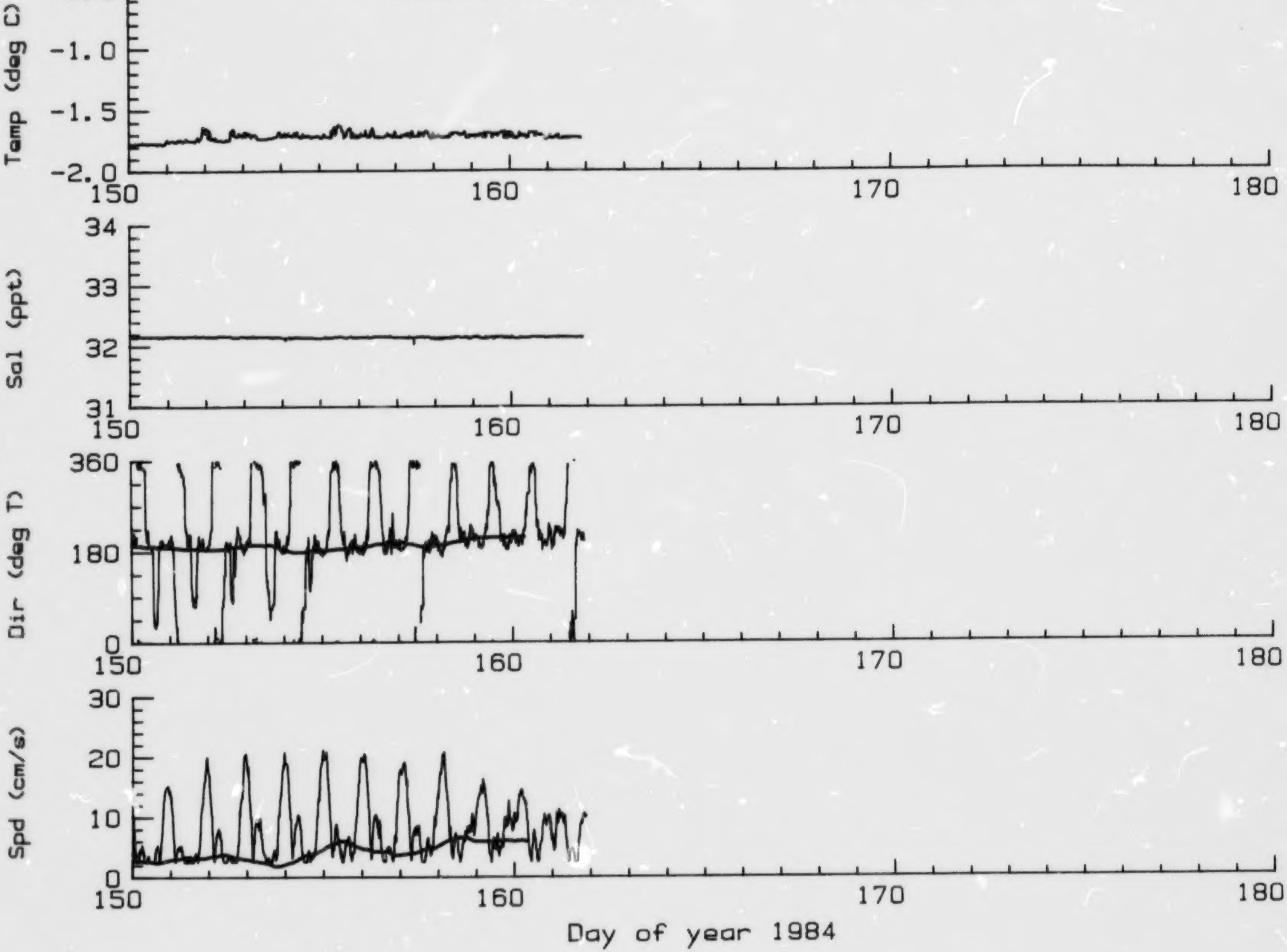

Station WC11 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984


Station WC11 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

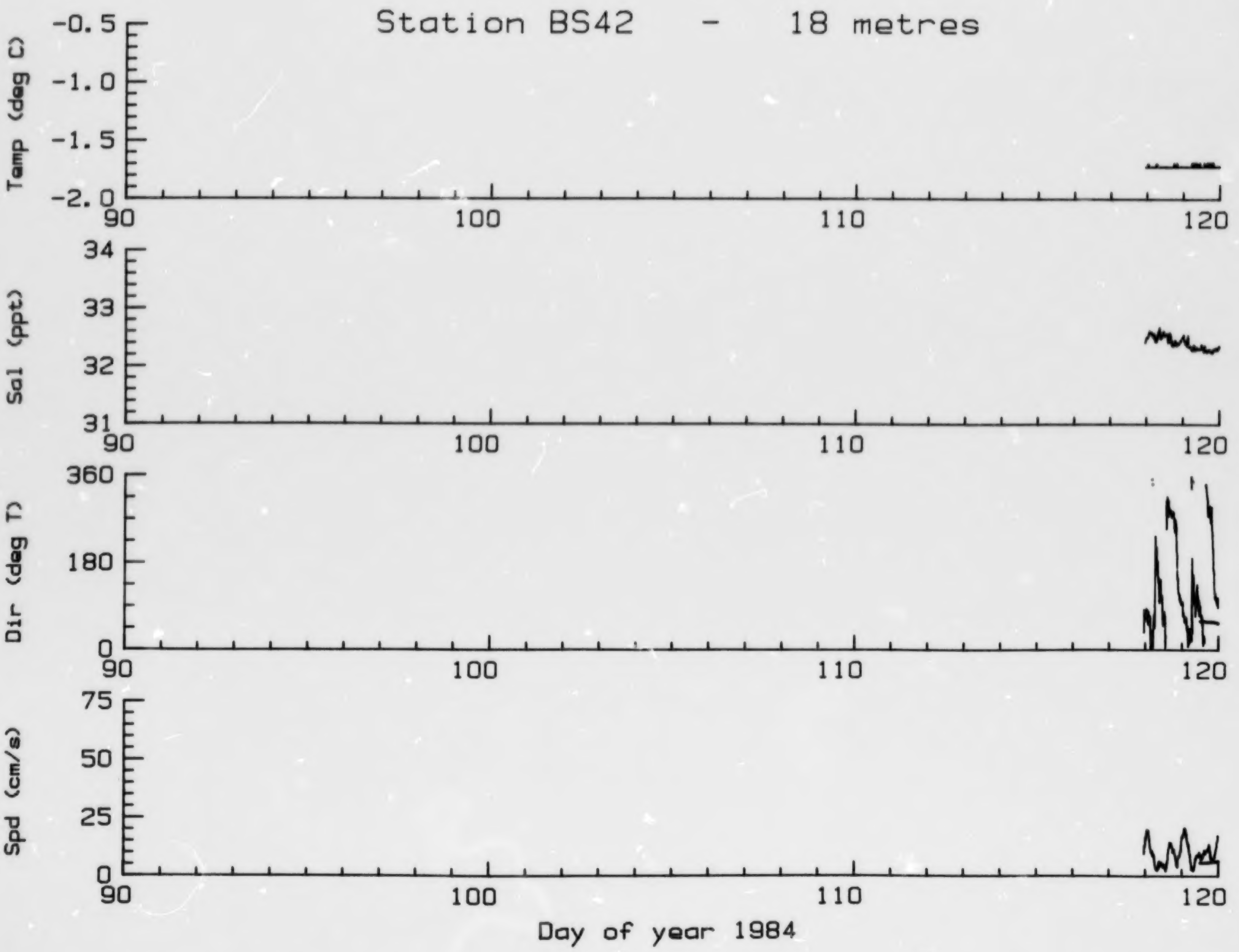

Station WC12 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1984

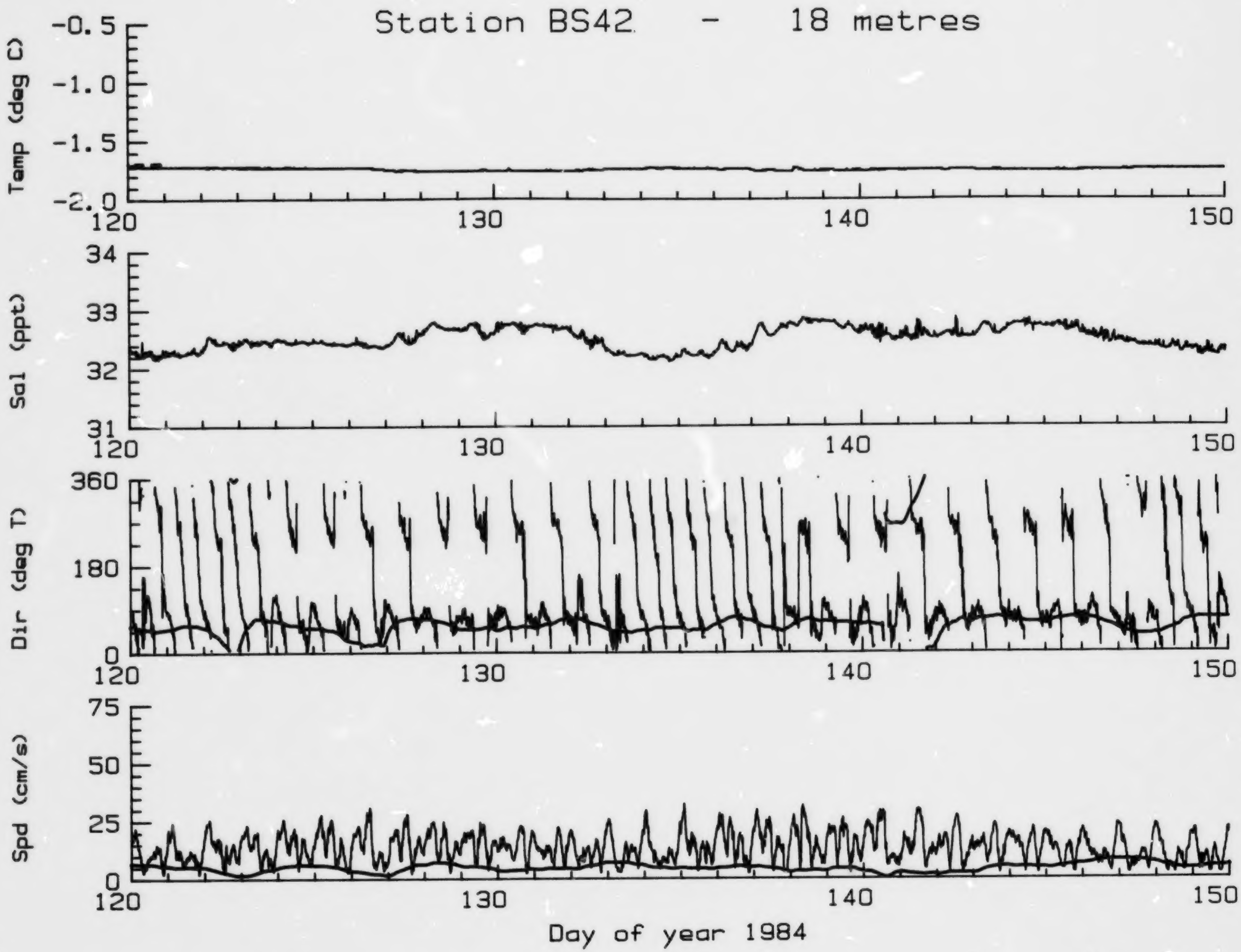

Station WC12 - 18 metr[illegible]
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
150
160
170
180
Day of year 1984

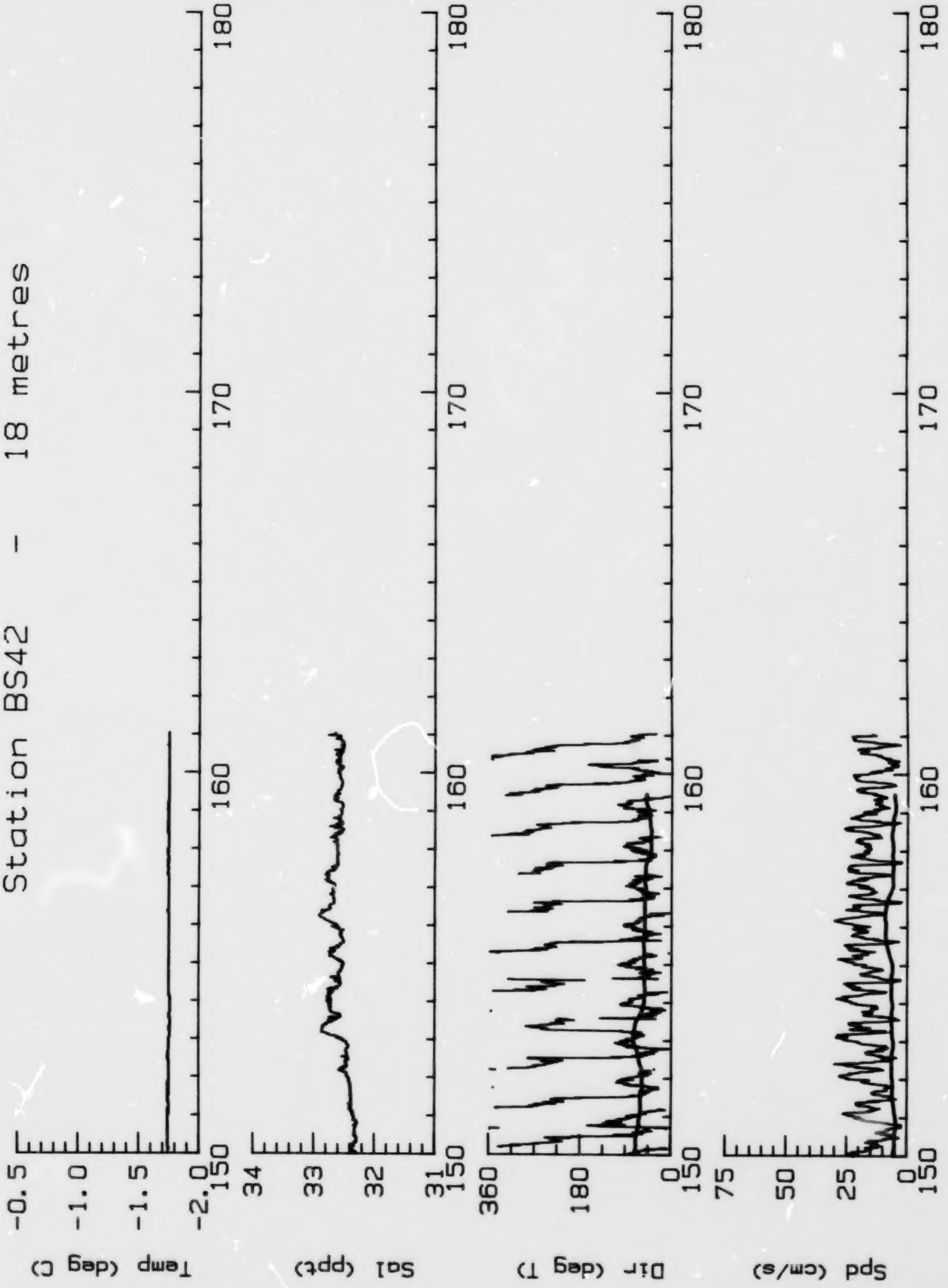

Station WC13 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
30
20
10
0
120
130
140
150
Day of year 1984

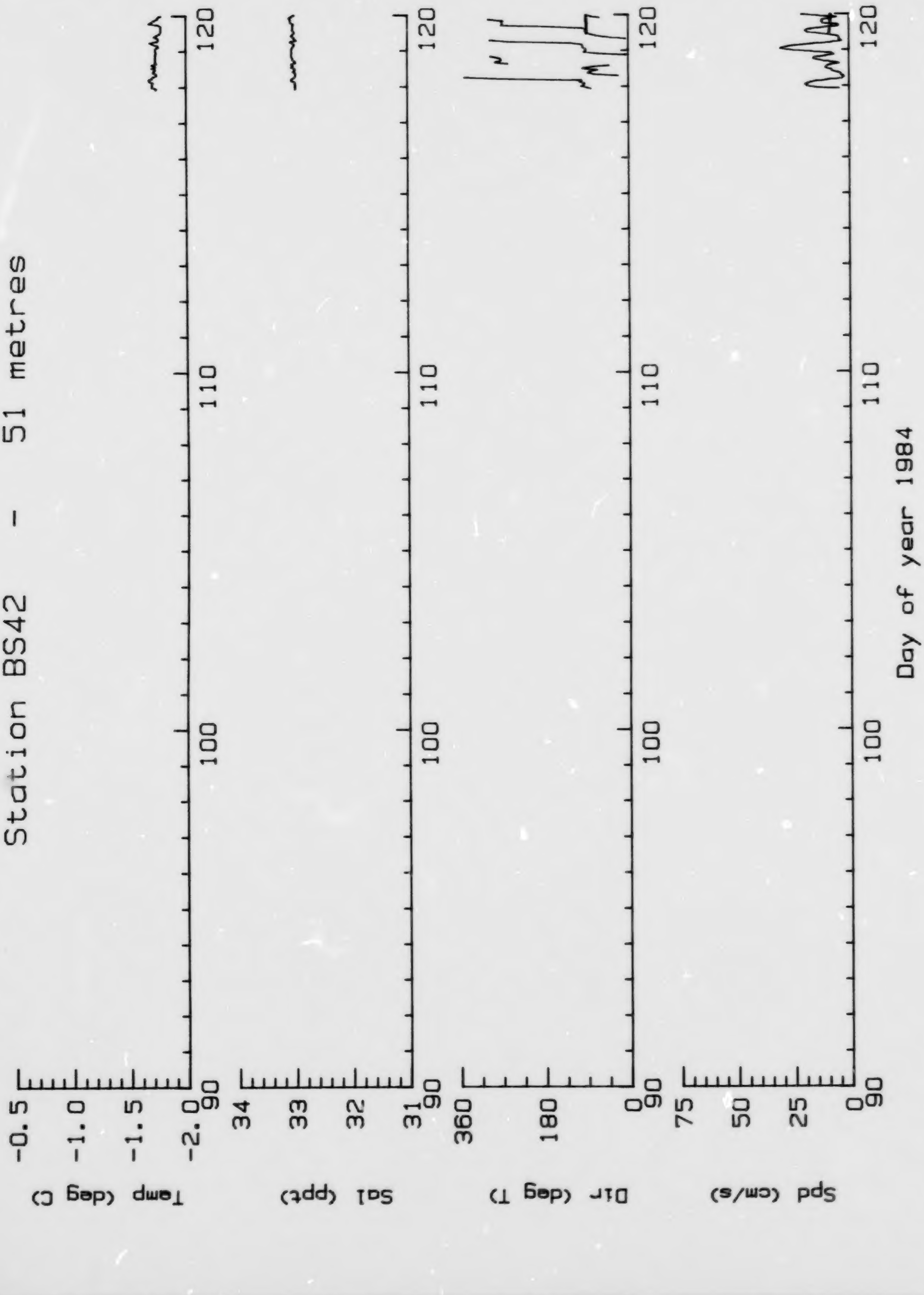


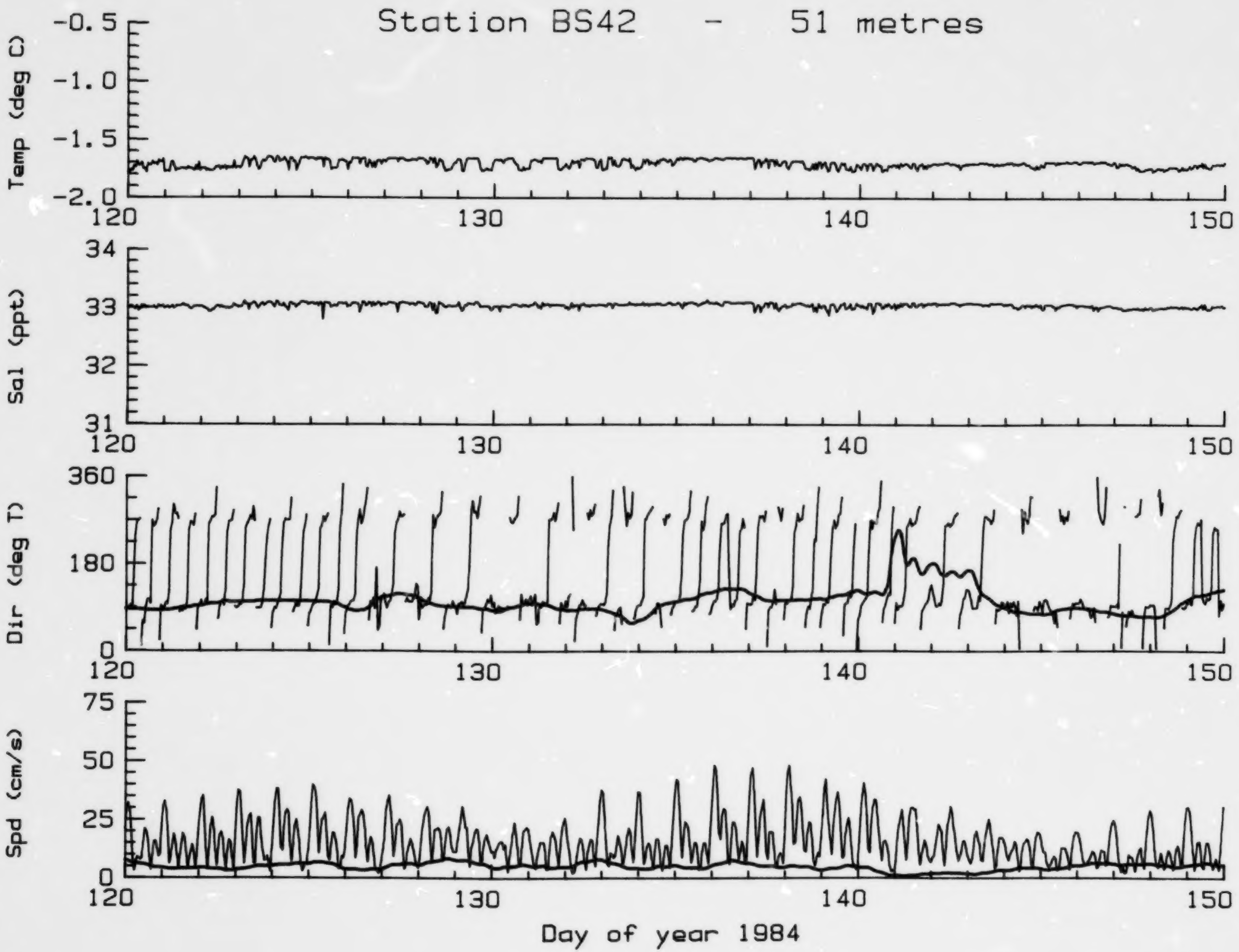
Station WC13 - 18 metres

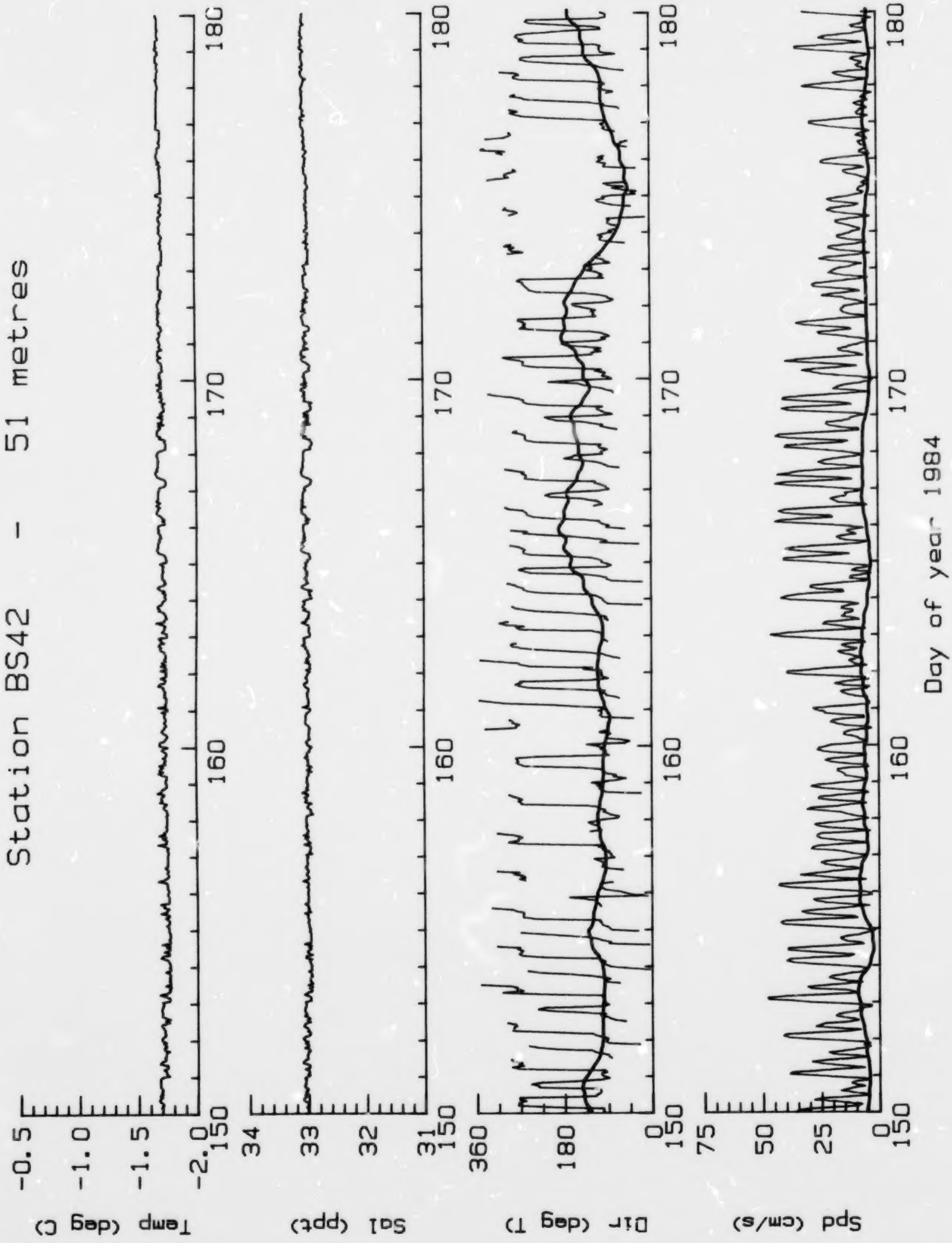

Station BS42 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984

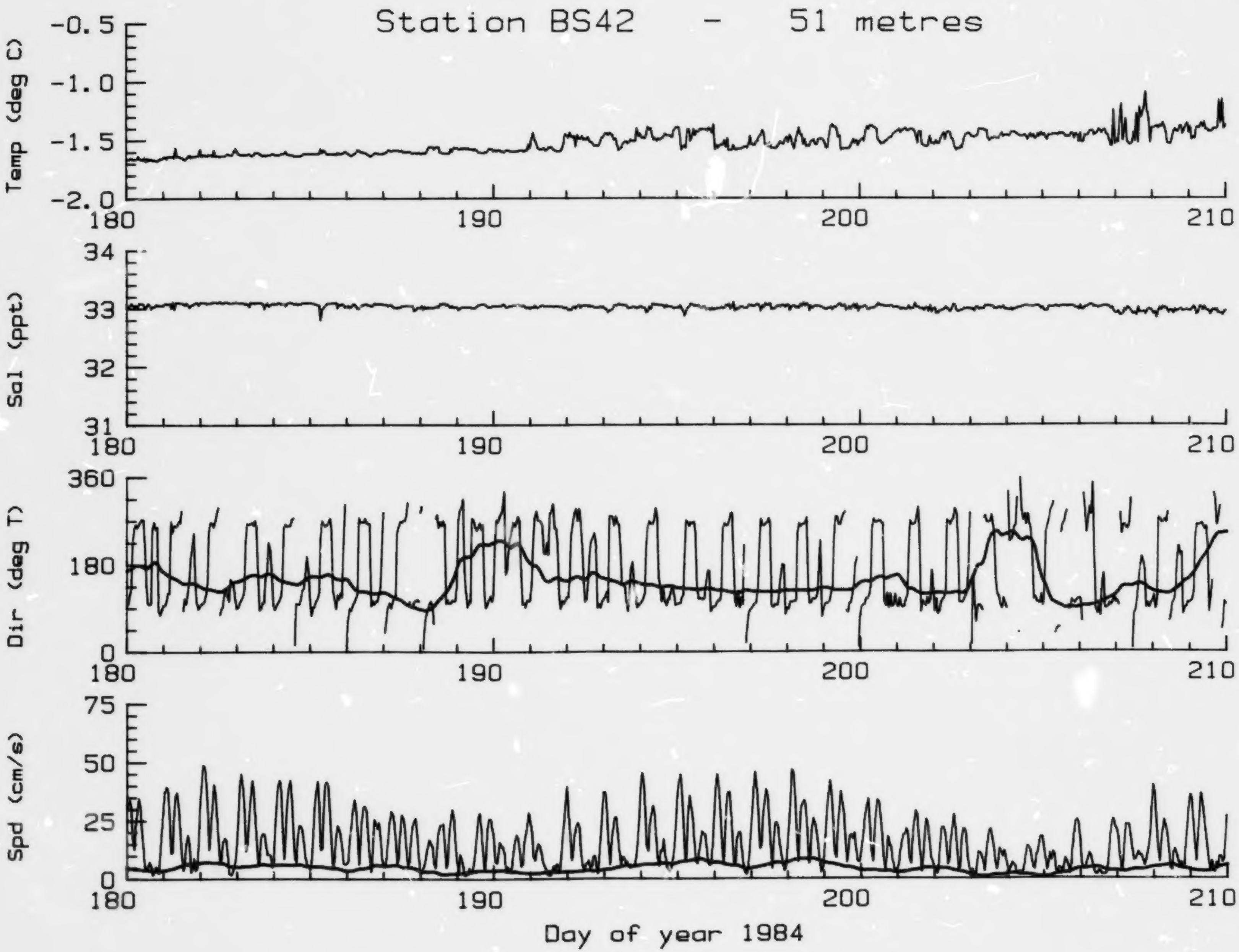

Station BS42 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984

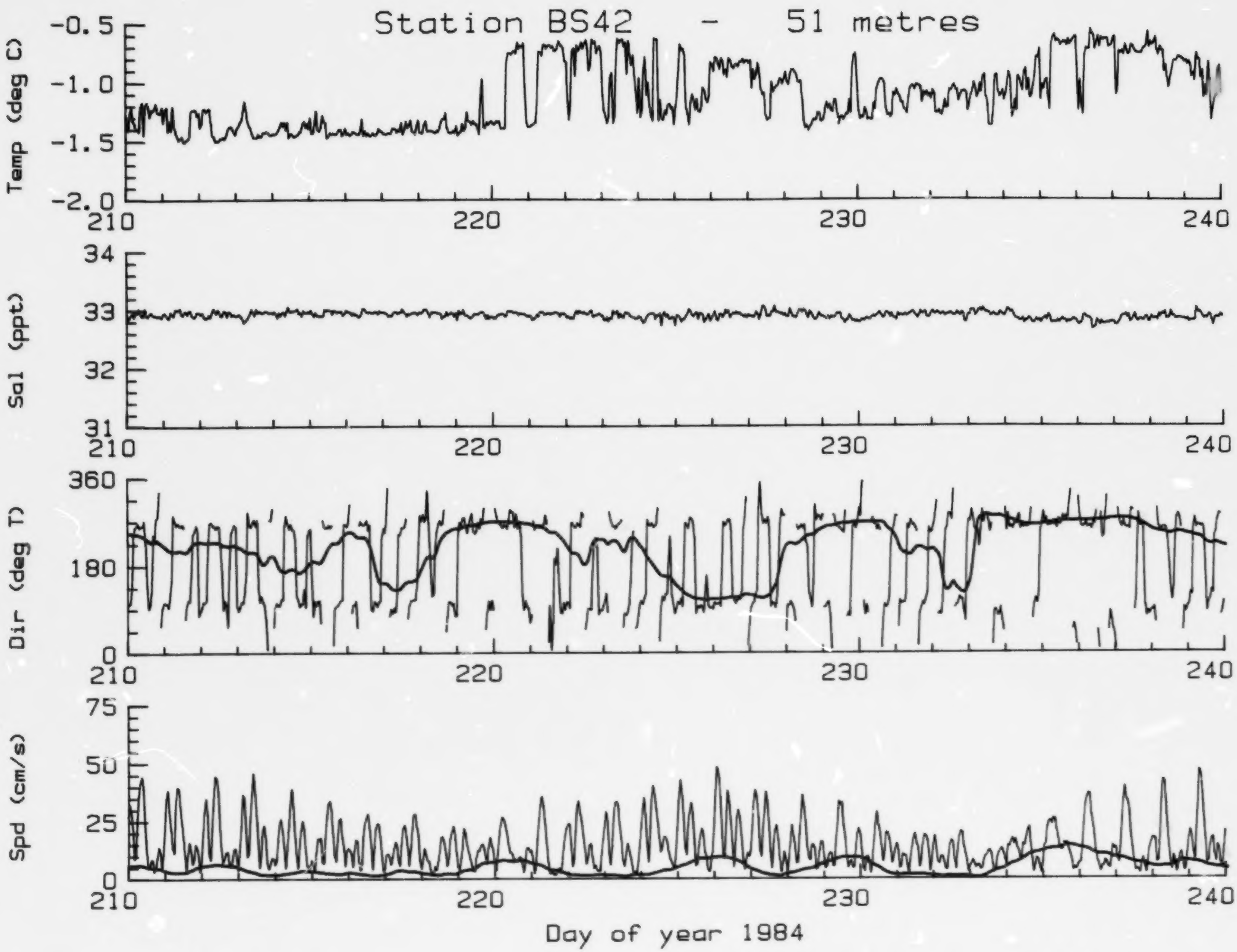

Station BS42 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

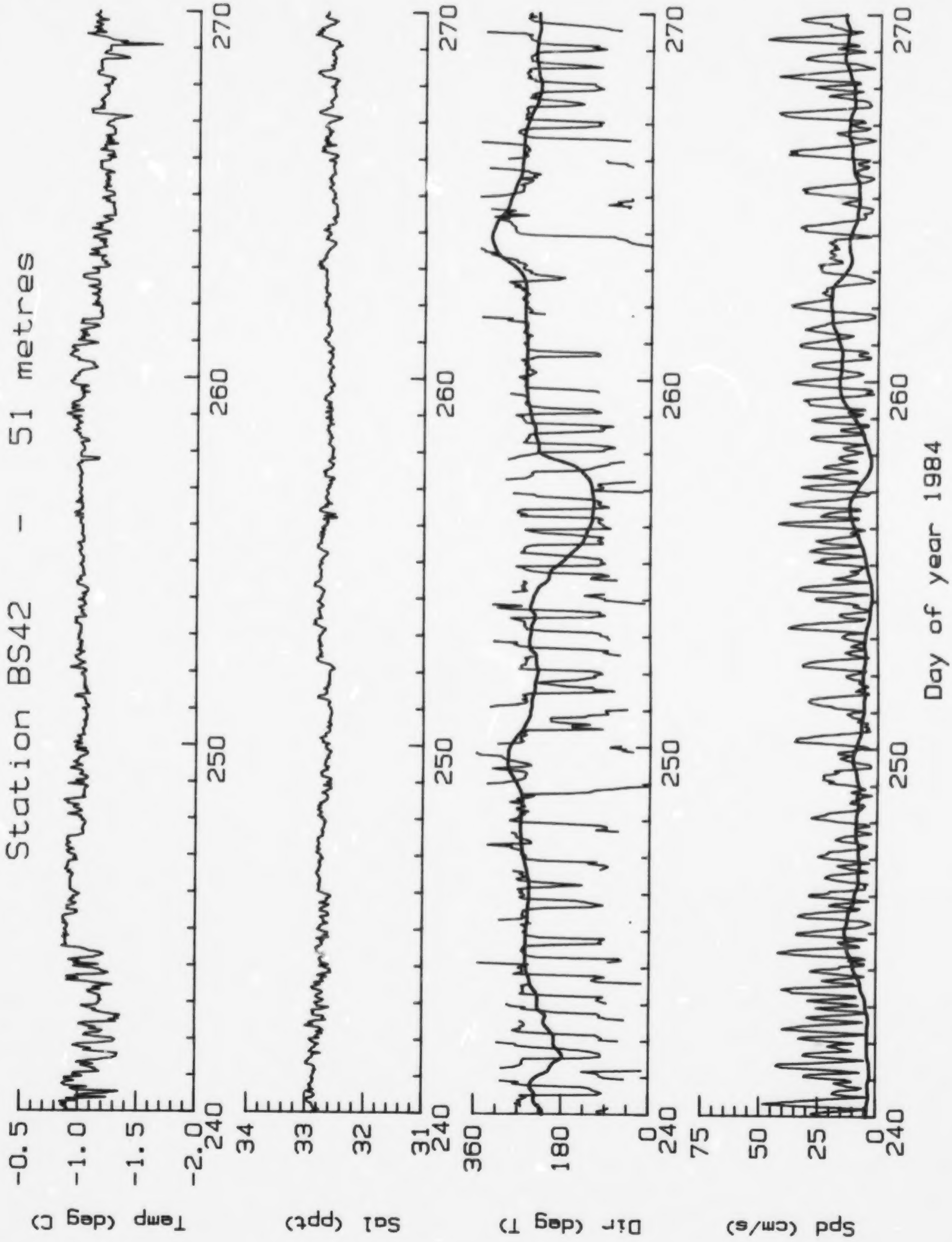

Station BS42 - 51 metres

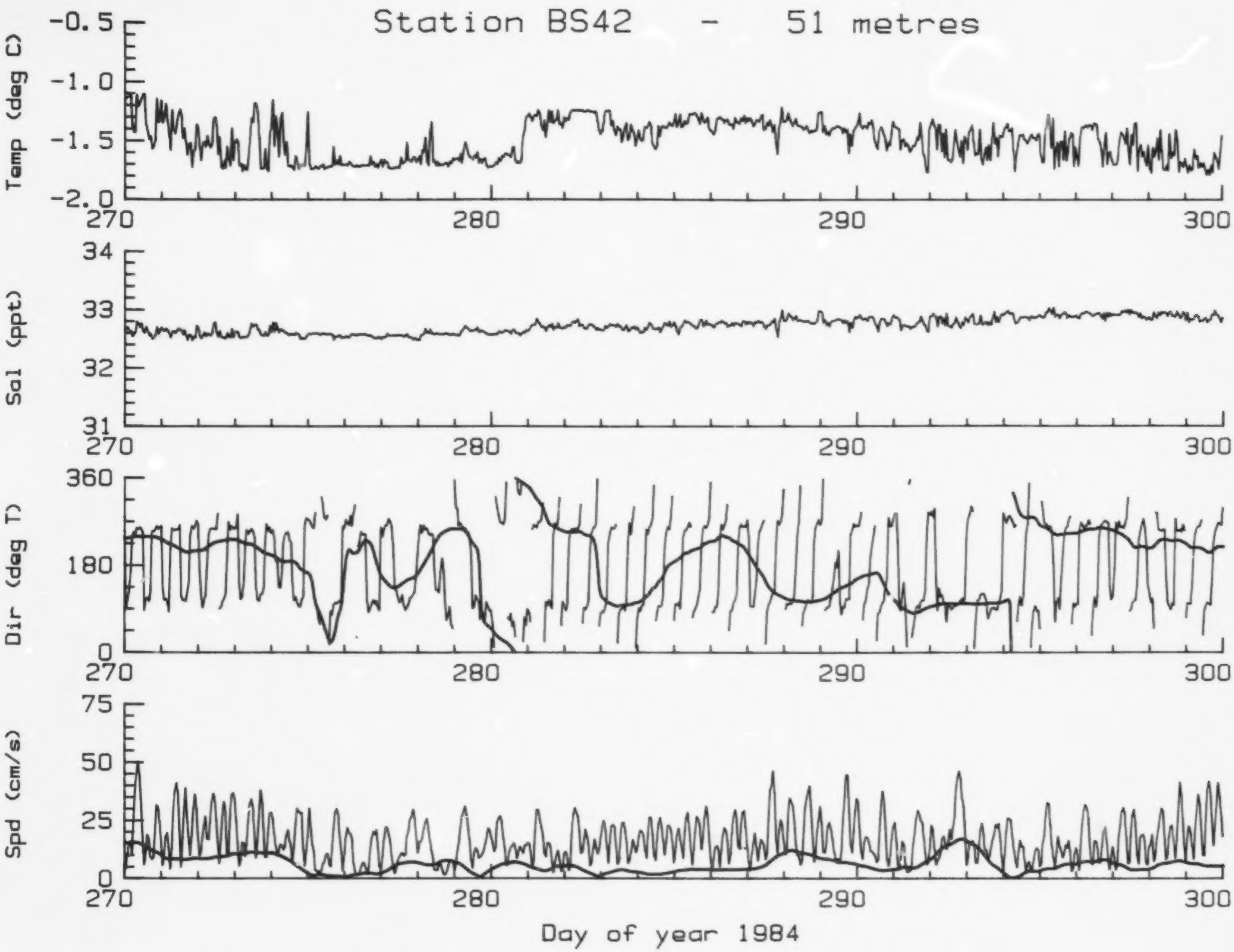

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984

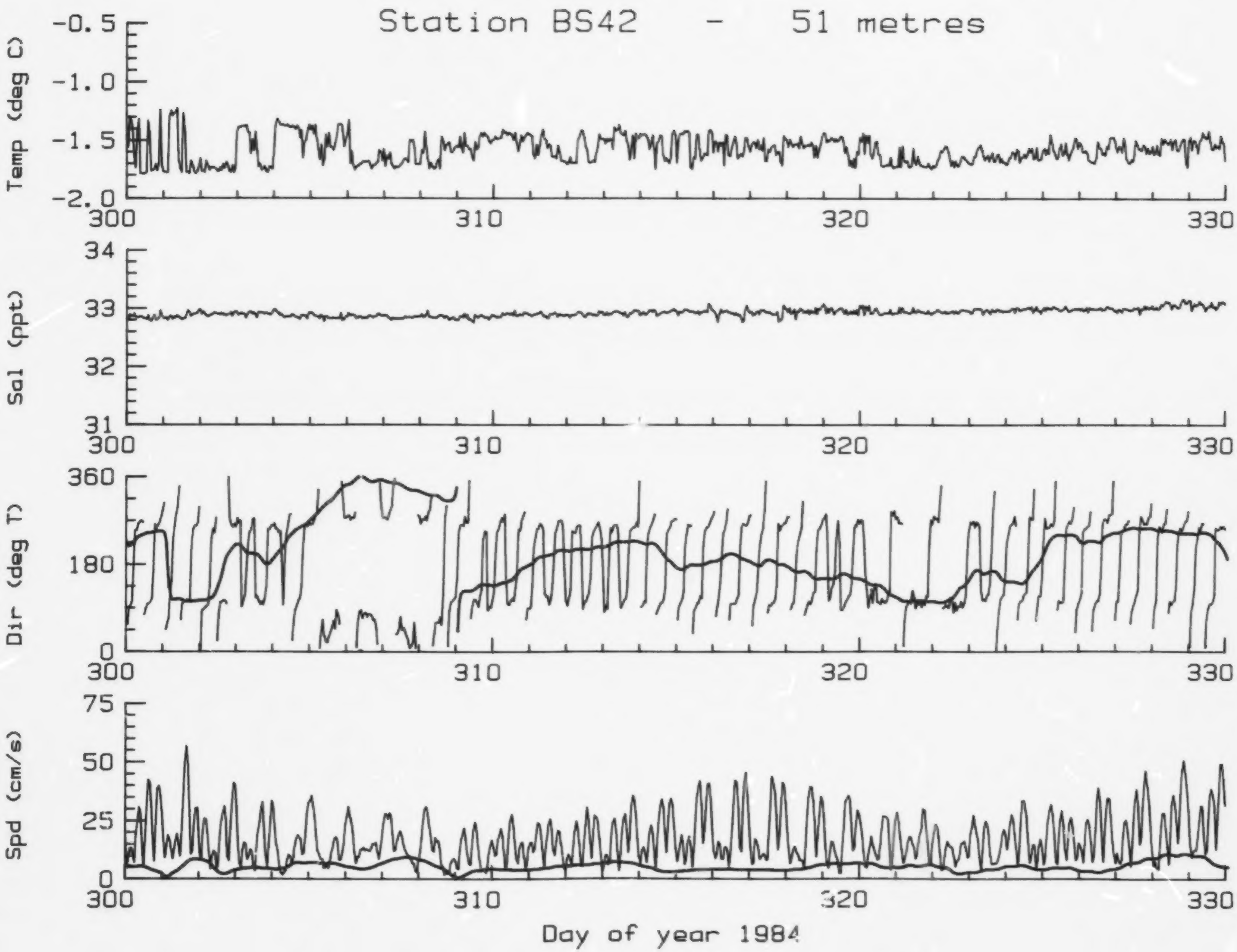

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

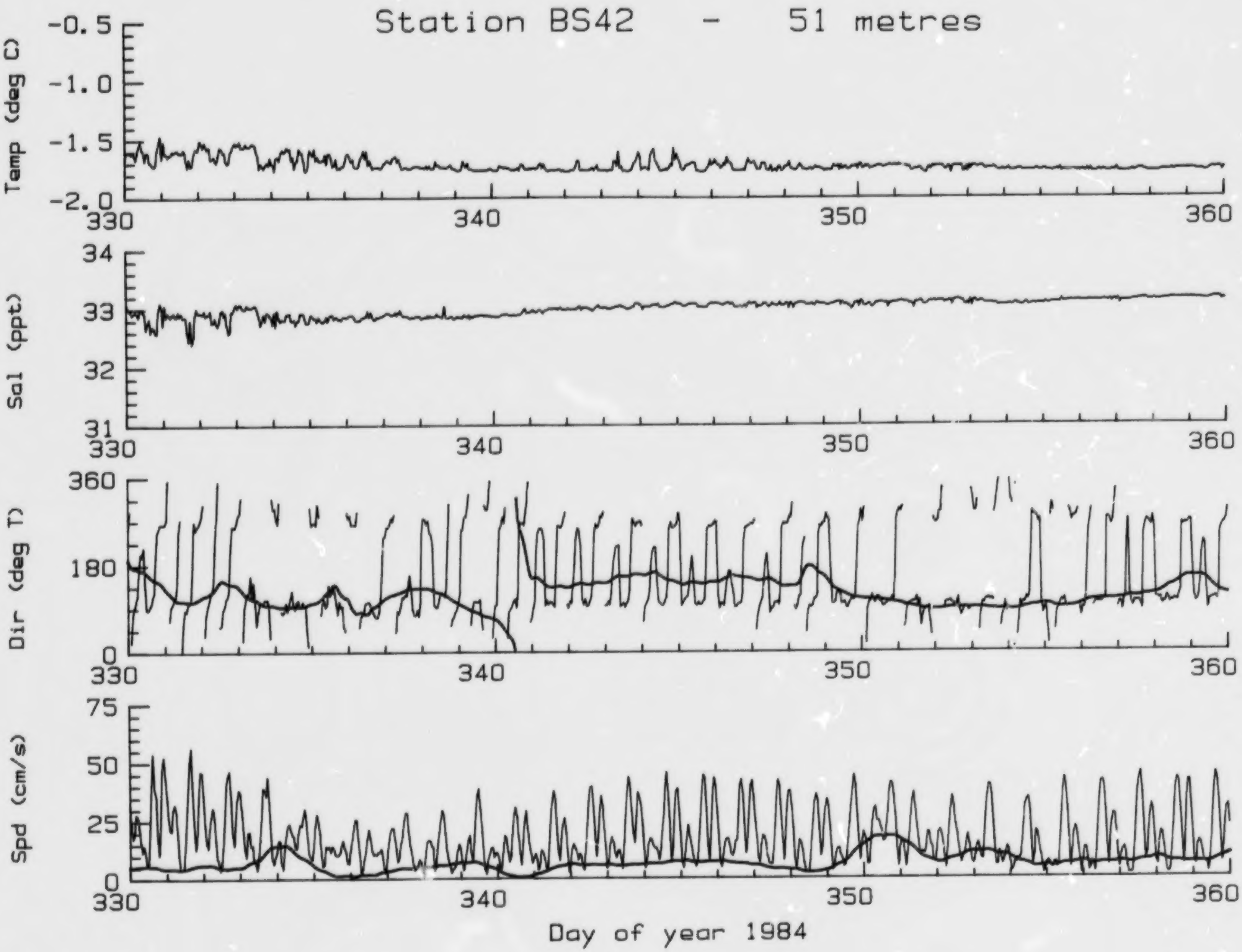

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
180
190
200
210
Day of year 1984

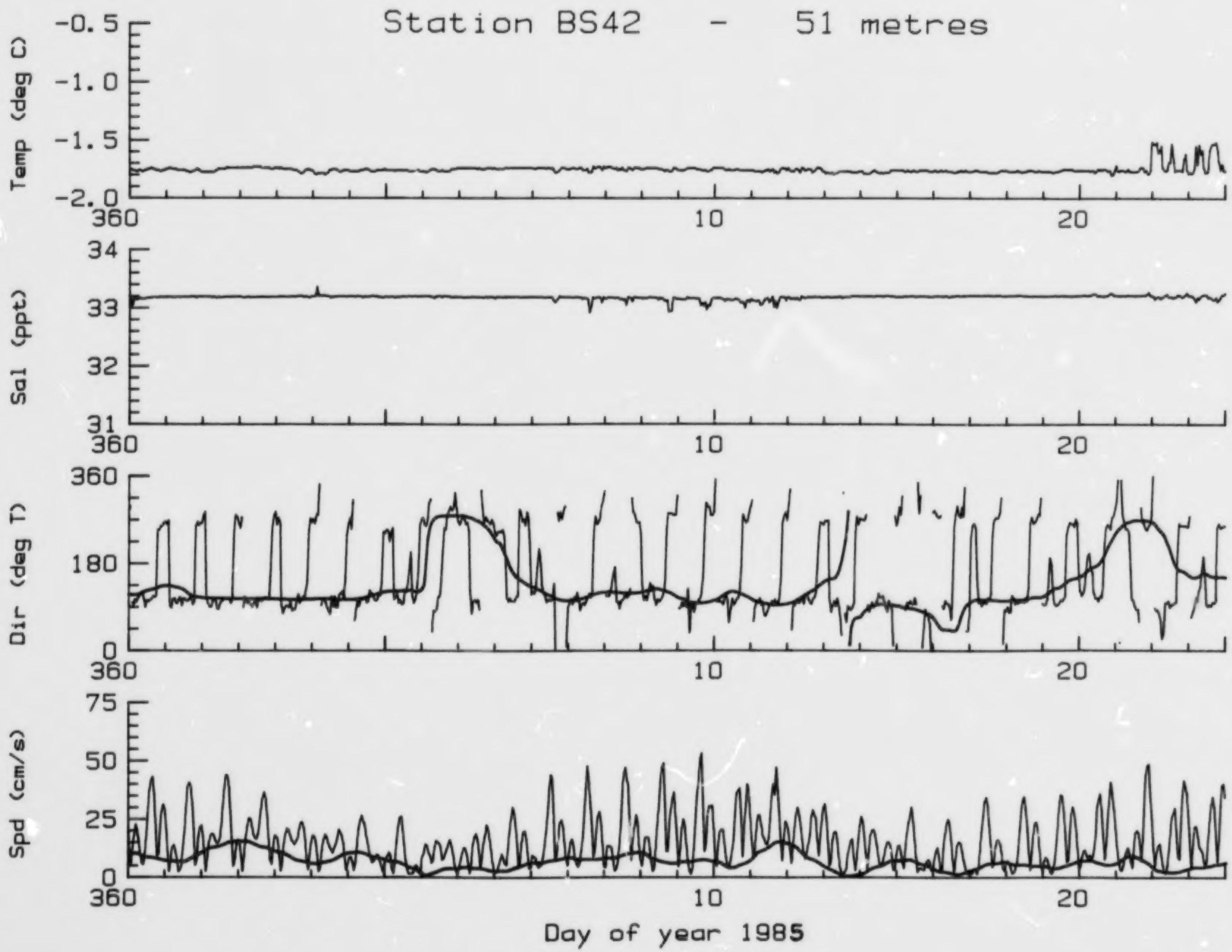

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
210
220
230
240
Day of year 1984

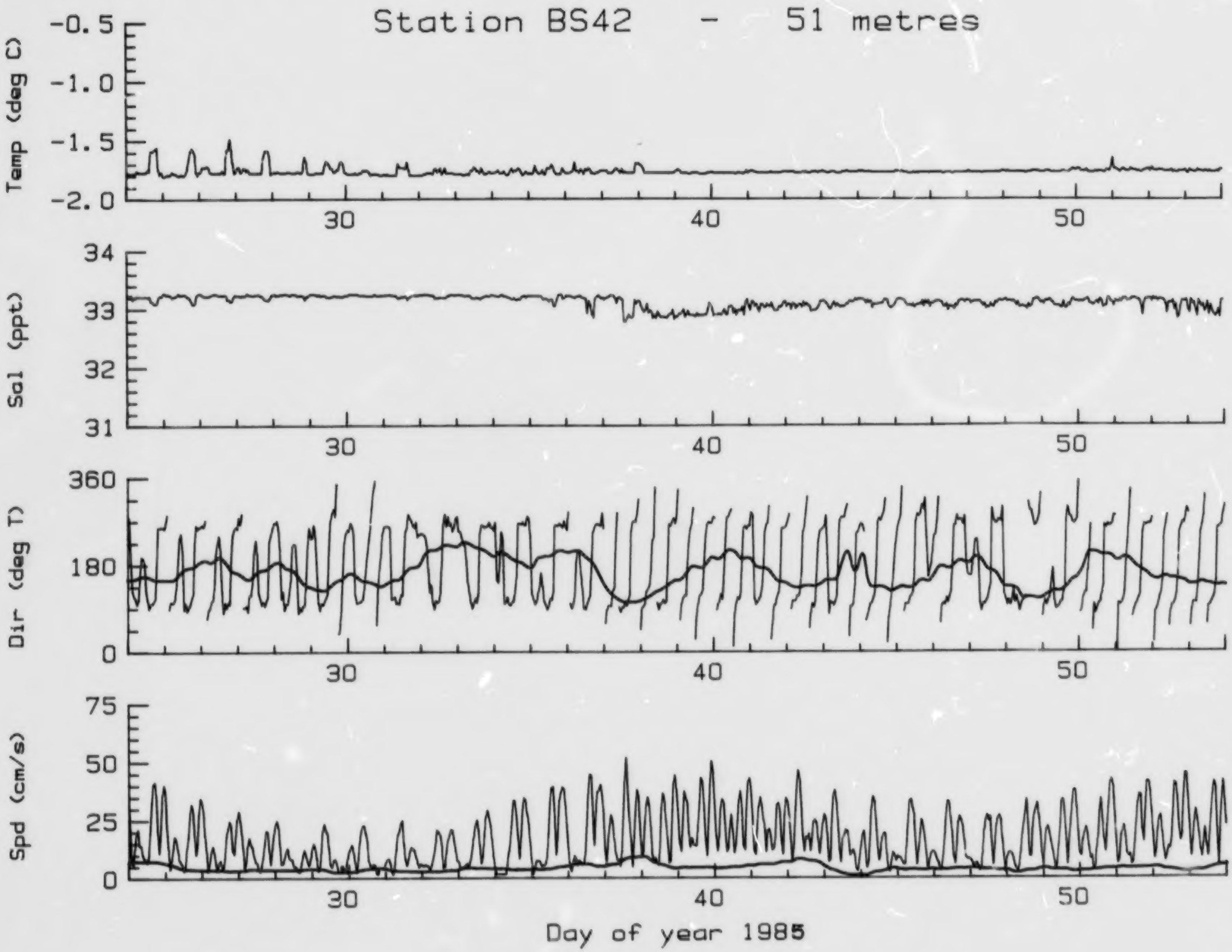

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
240
250
260
270
Day of year 1984


Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
270
280
290
300
Day of year 1984

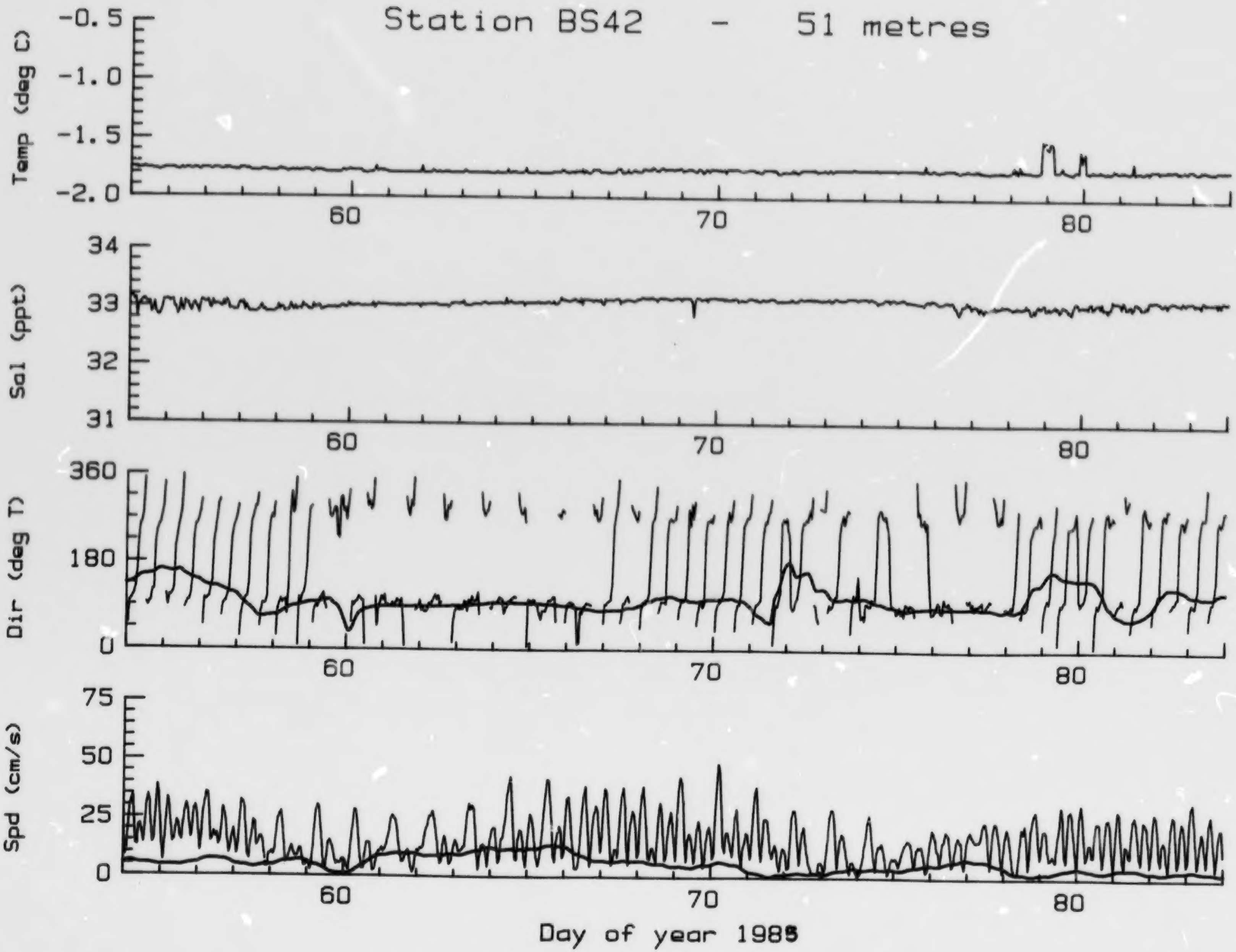

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
300
310
320
330
Day of year 1984


Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
330
340
350
360
Day of year 1984

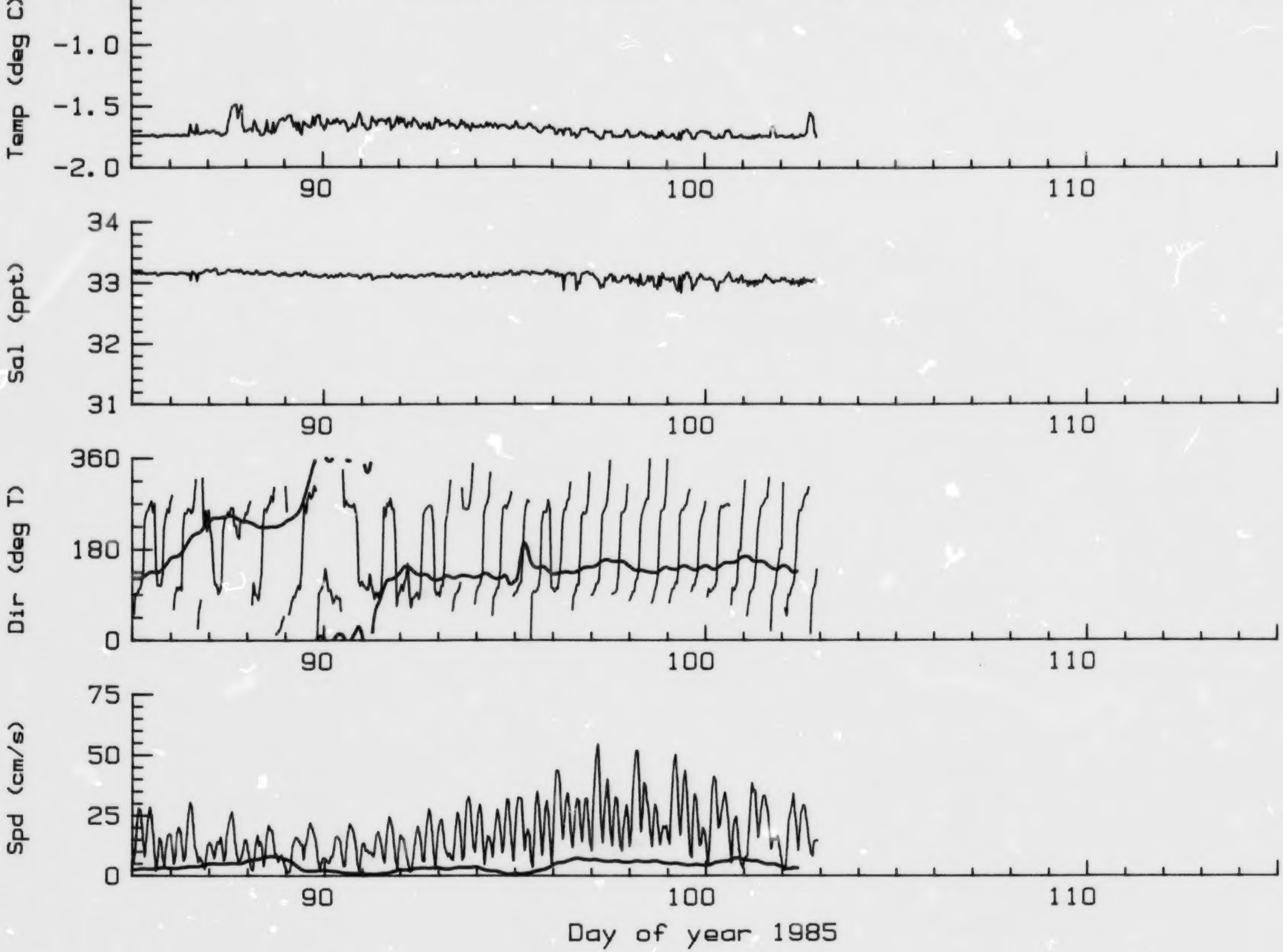

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
360
10
20
Day of year 1985

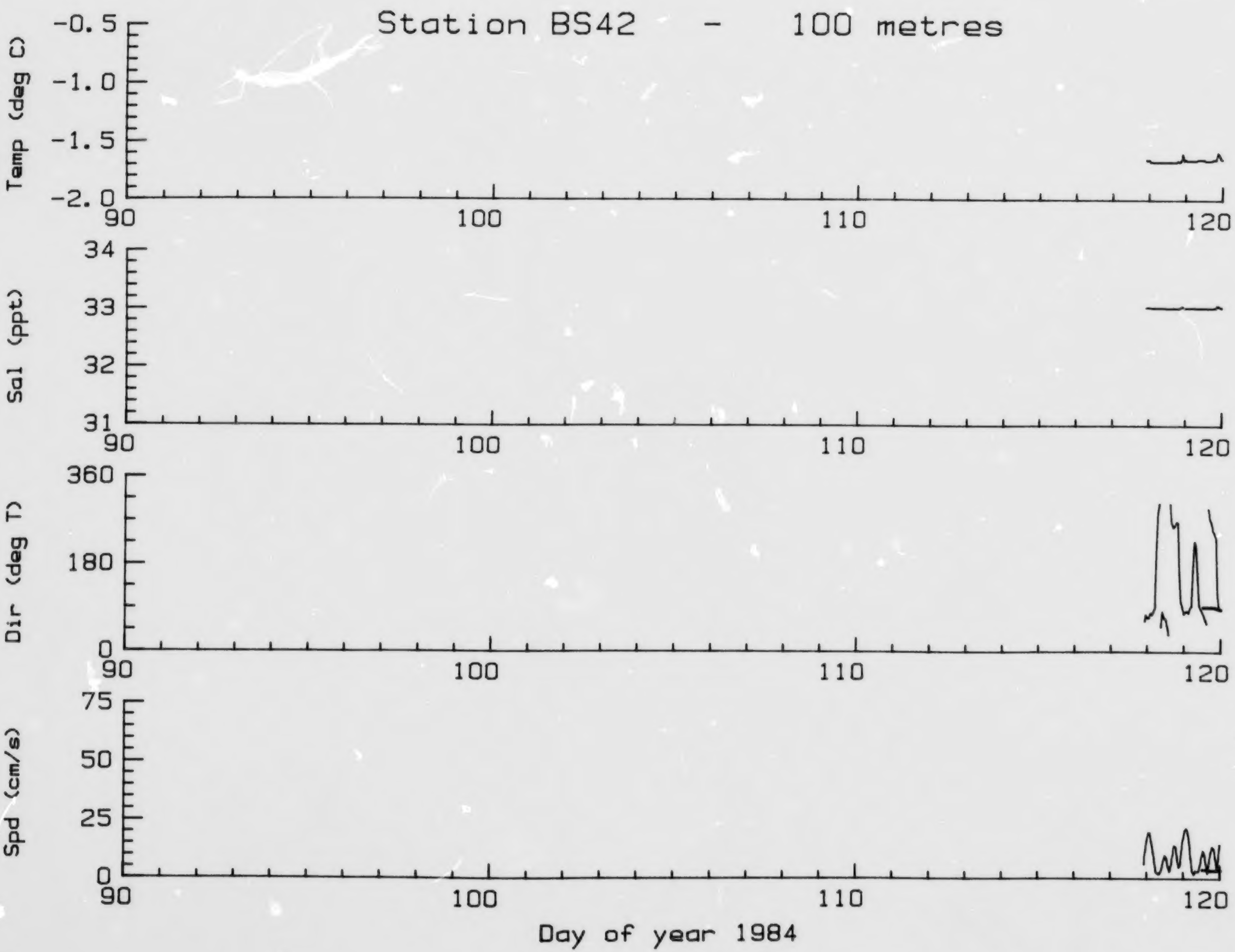


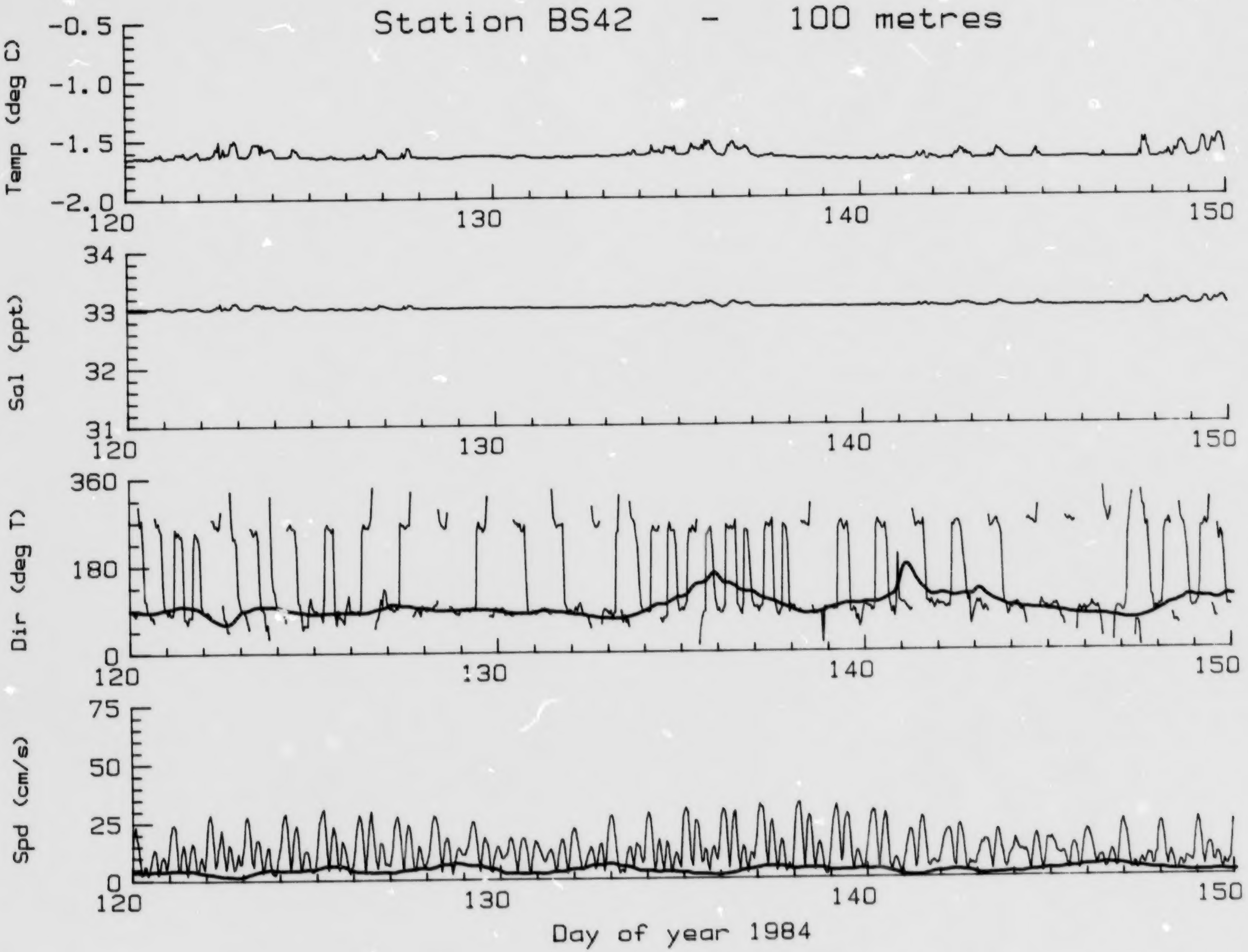
Station BS42 - 51 metres

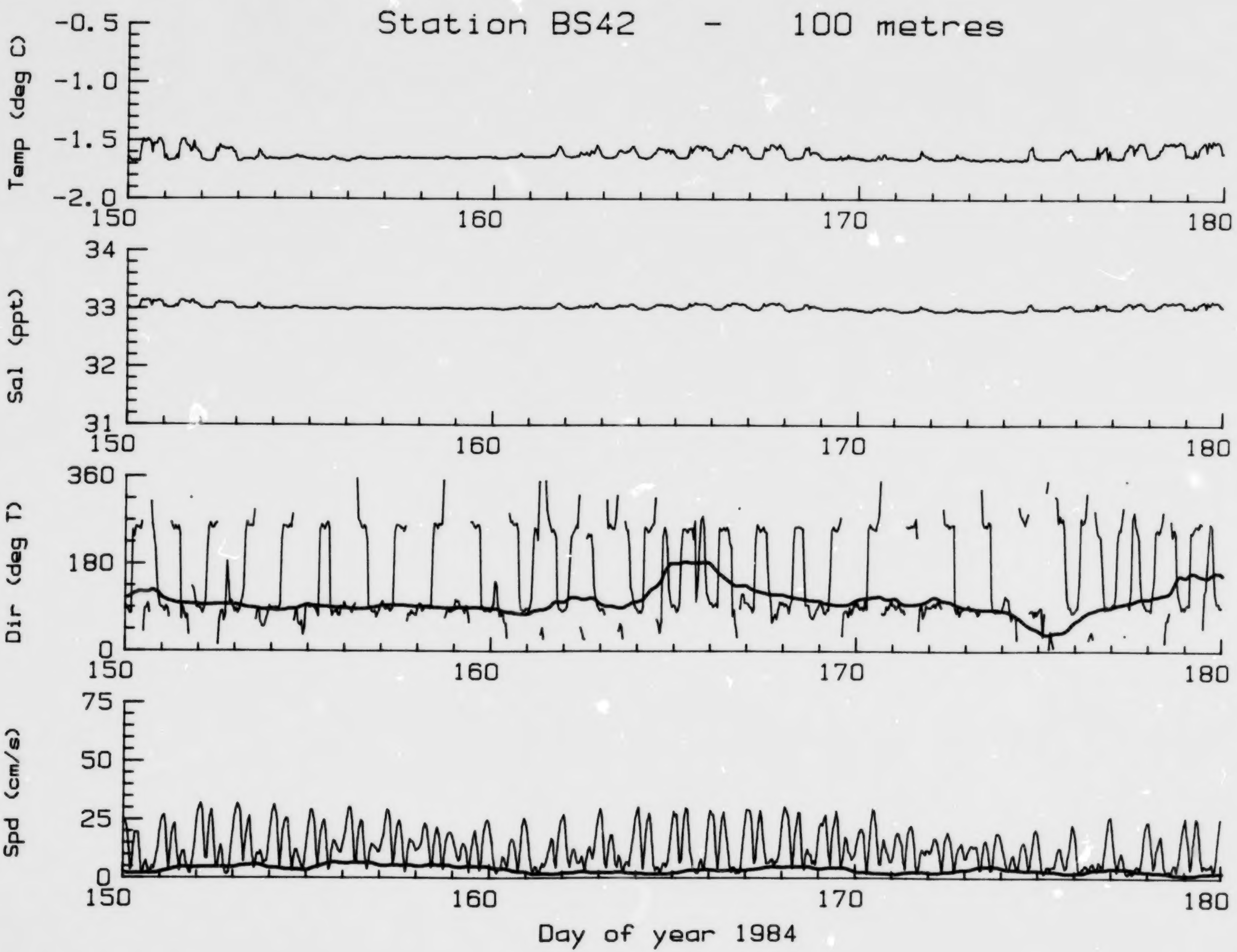

Station BS42 - 51 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
60
70
80
Day of year 1985

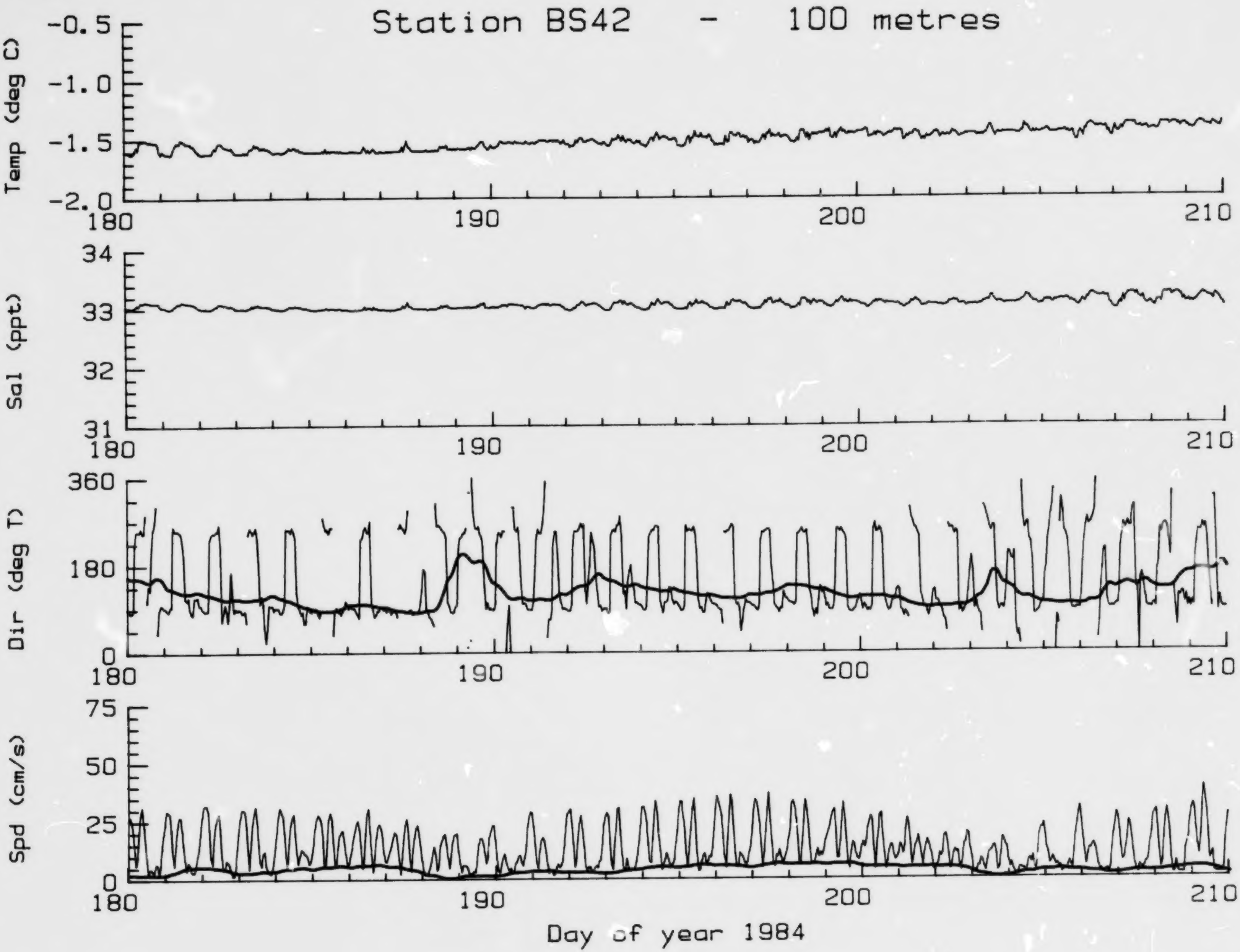
Station BS42 - 51 metres



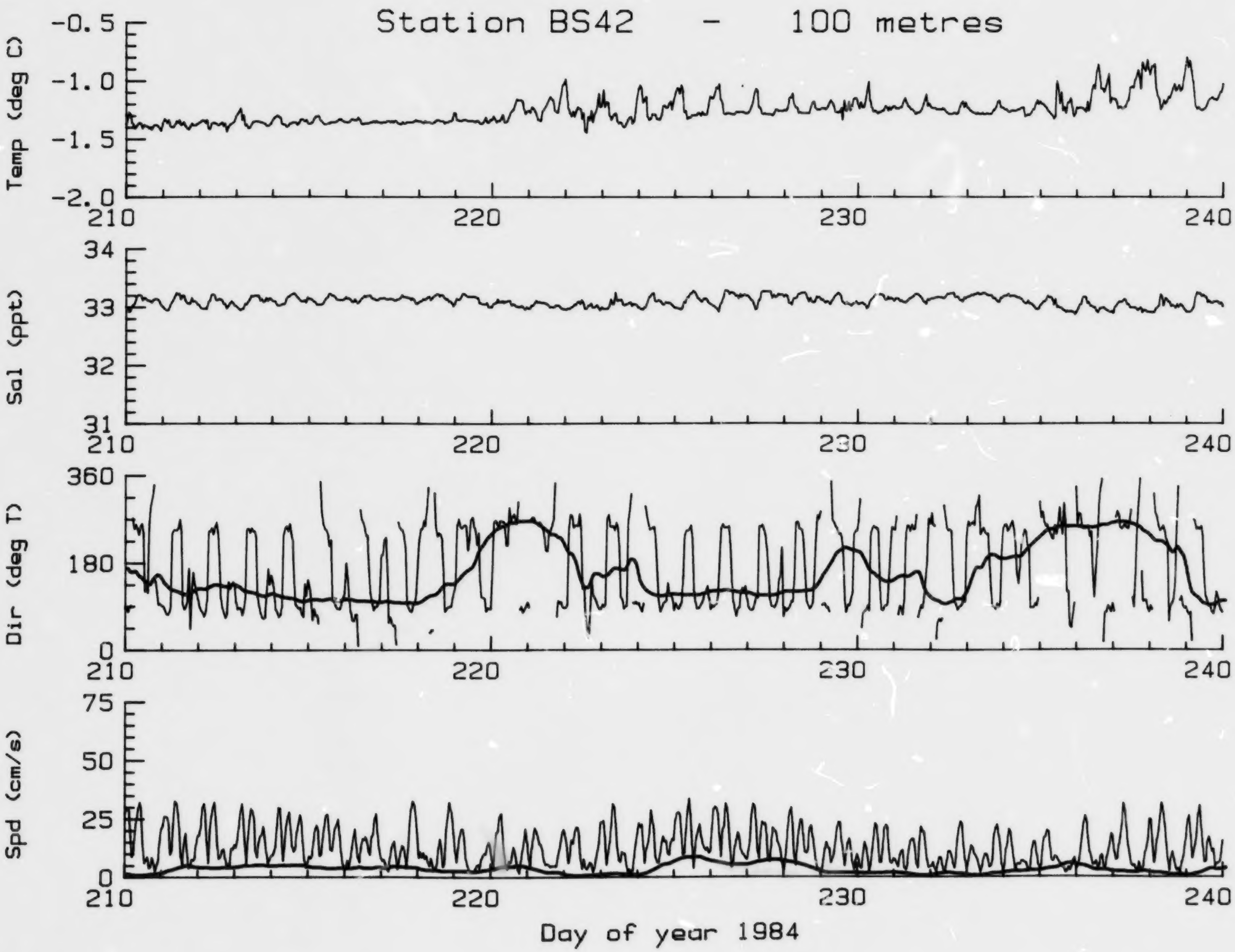

Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984


Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984

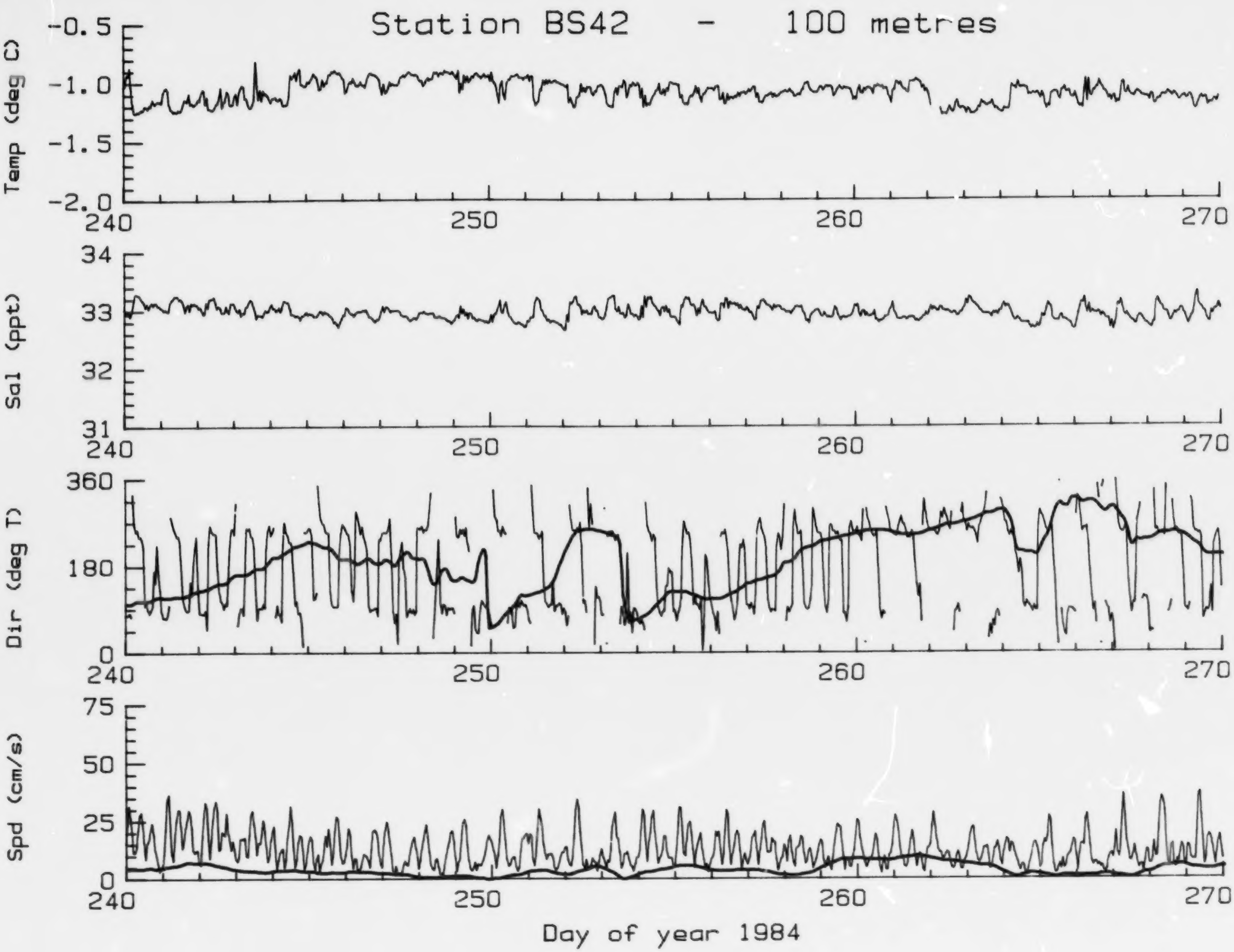

Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

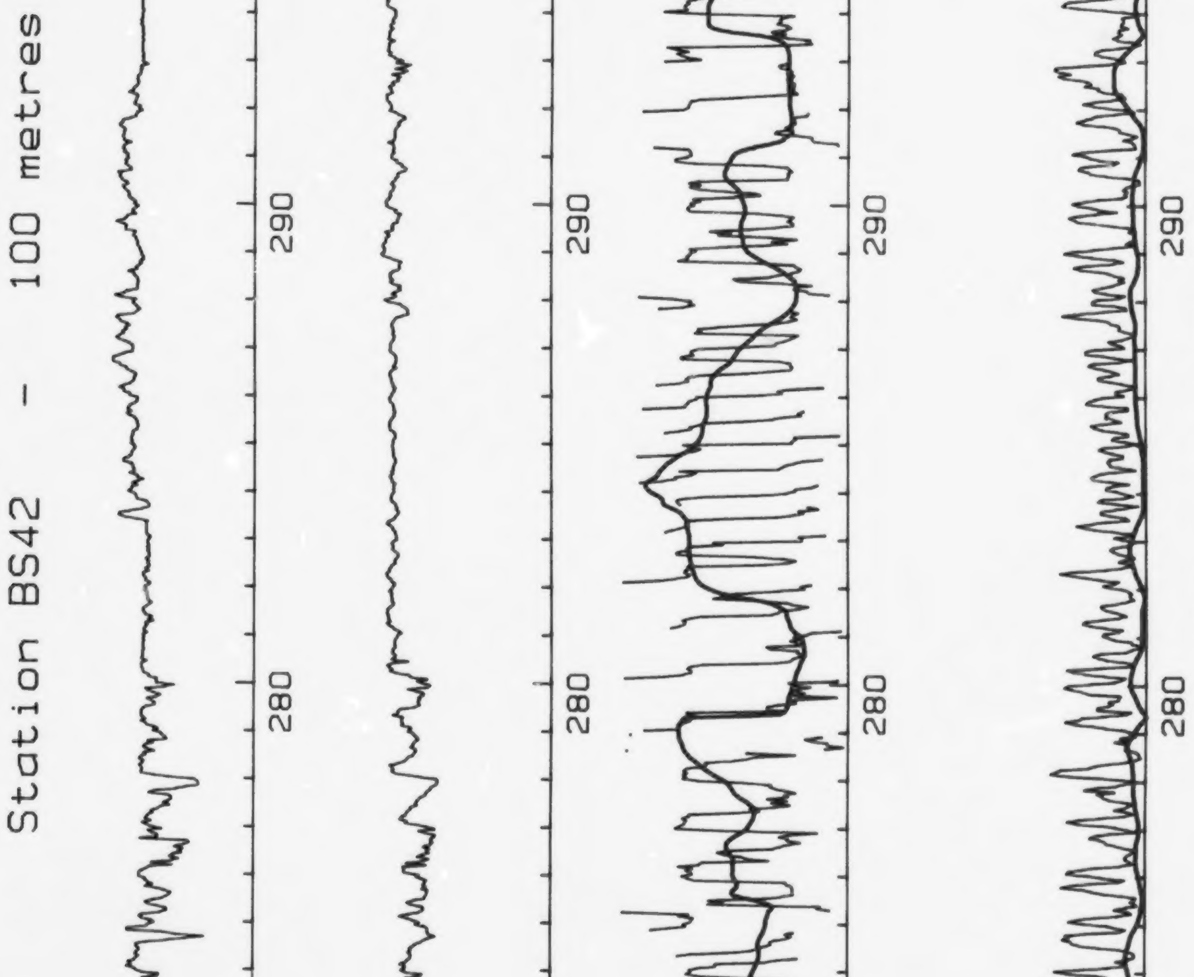


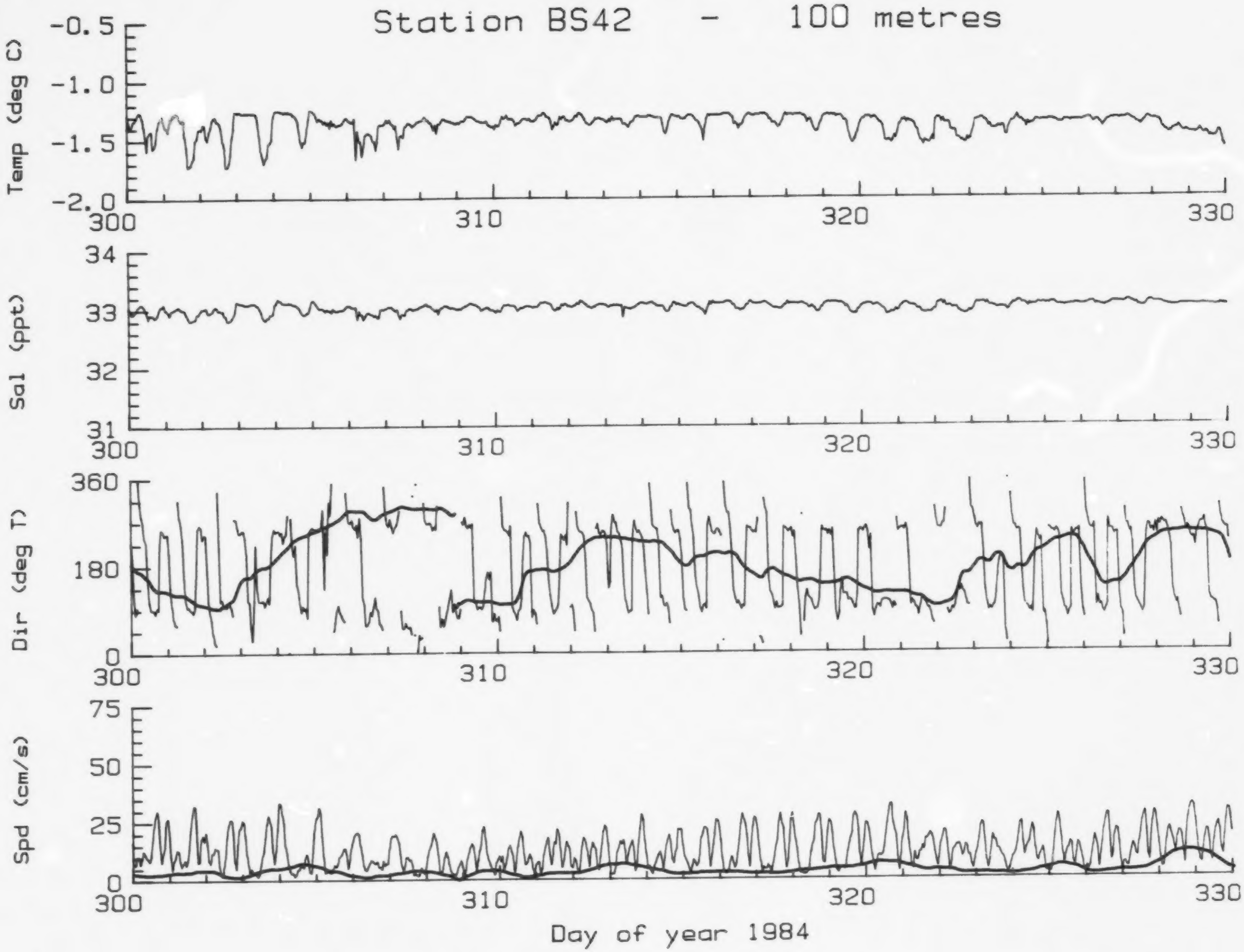
Station BS42 - 100 metres

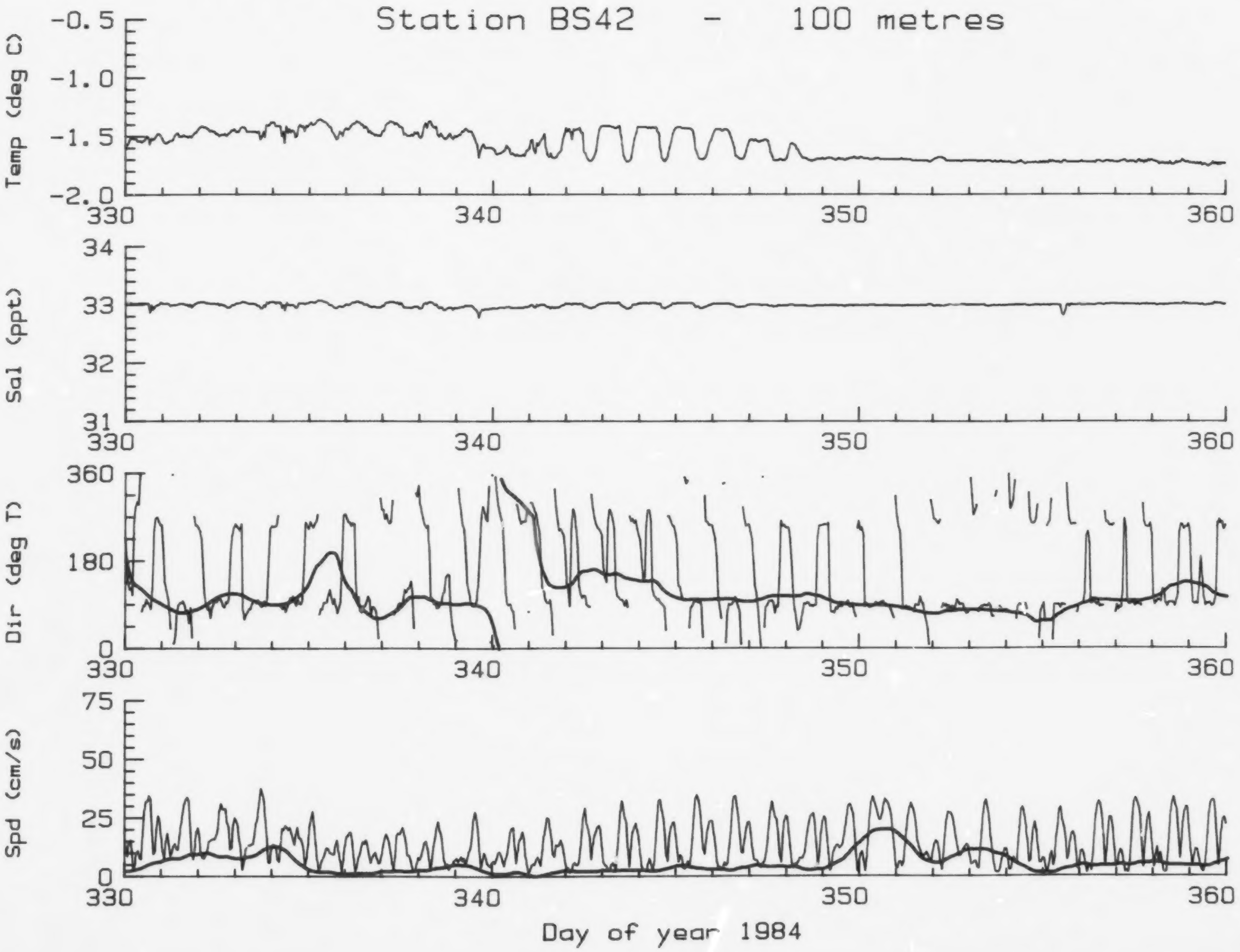


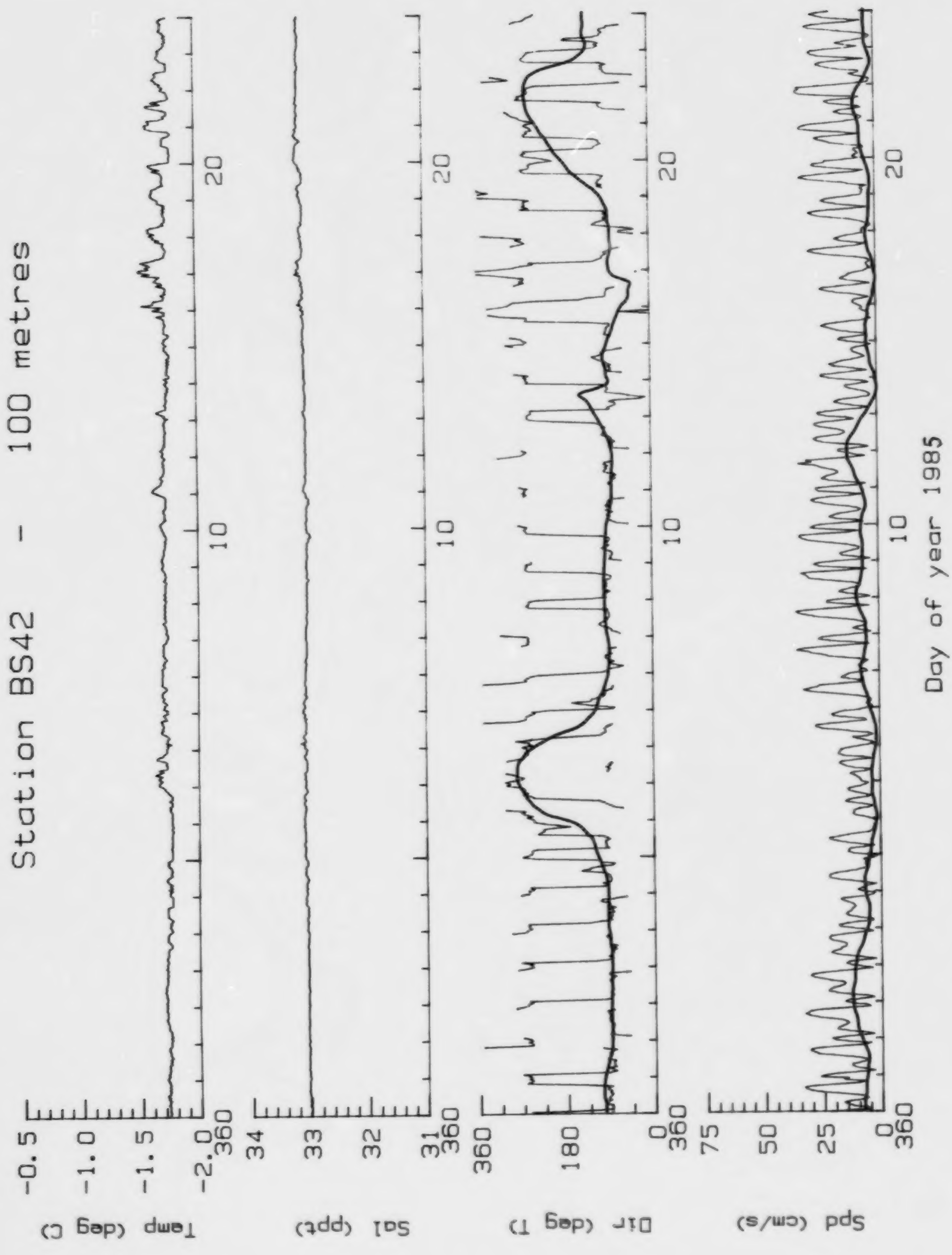
Station BS42 - 100 metres

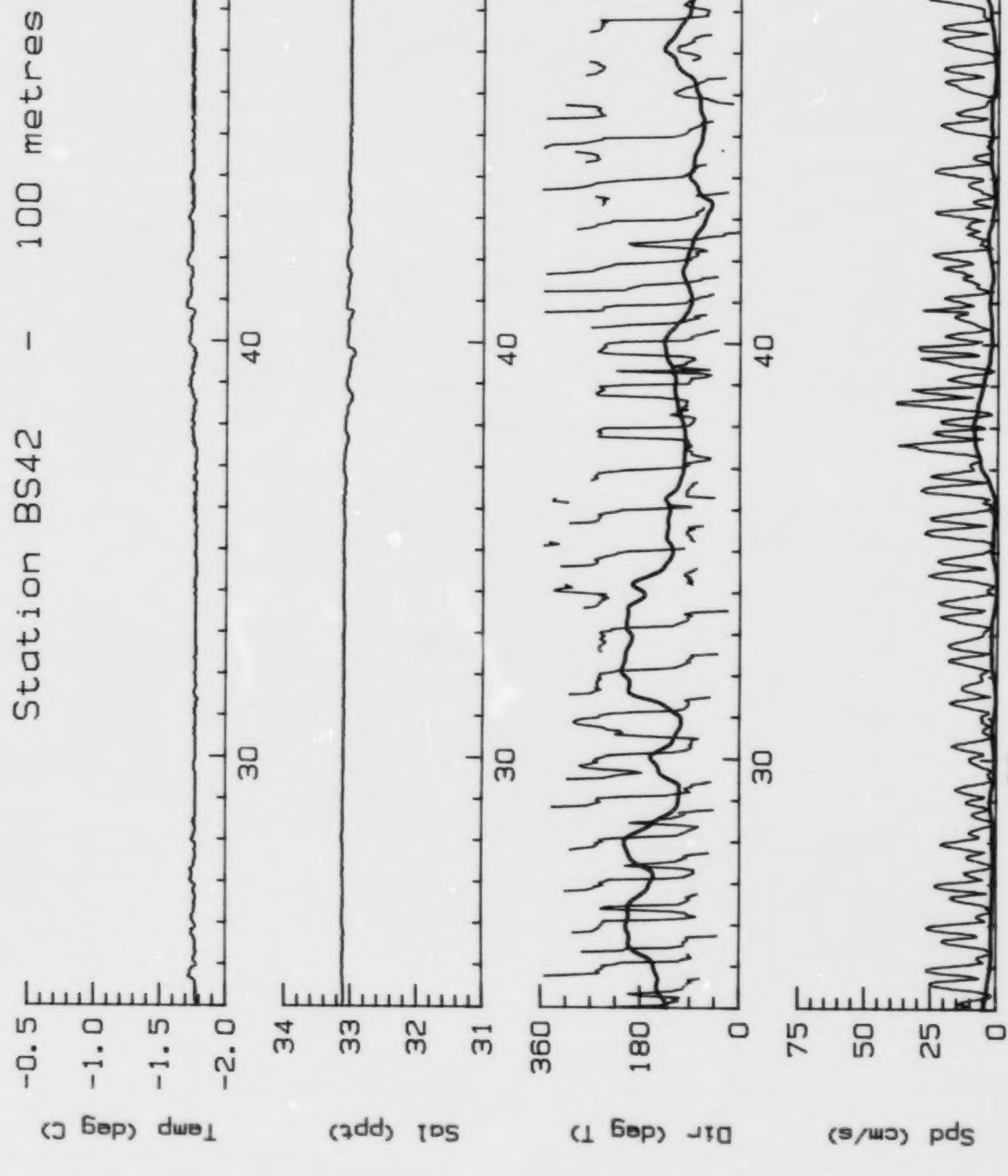

Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
240
250
260
270
Day of year 1984


Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
270
280
290
300
Day of year 1984

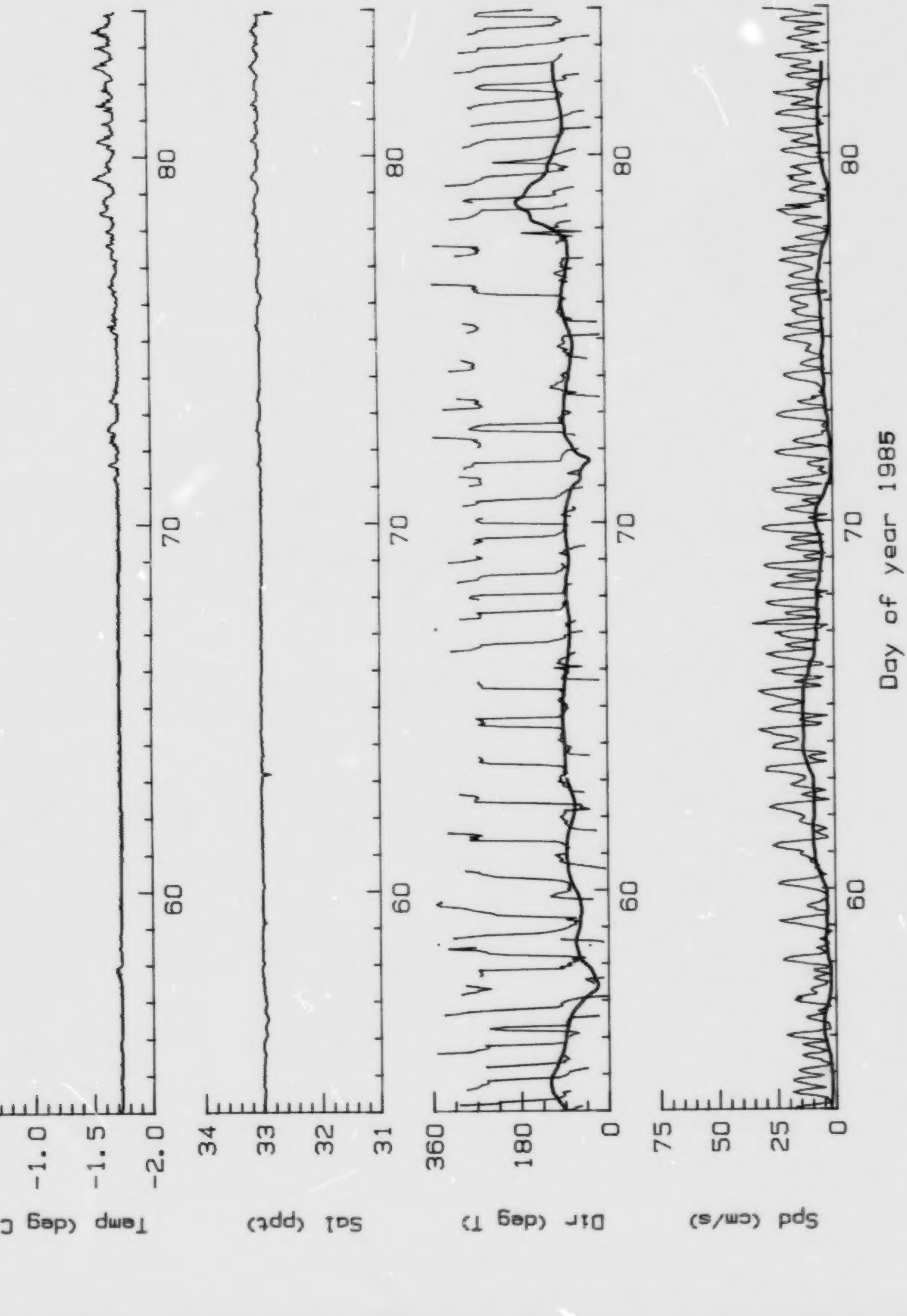

Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
300
310
320
330
Day of year 1984

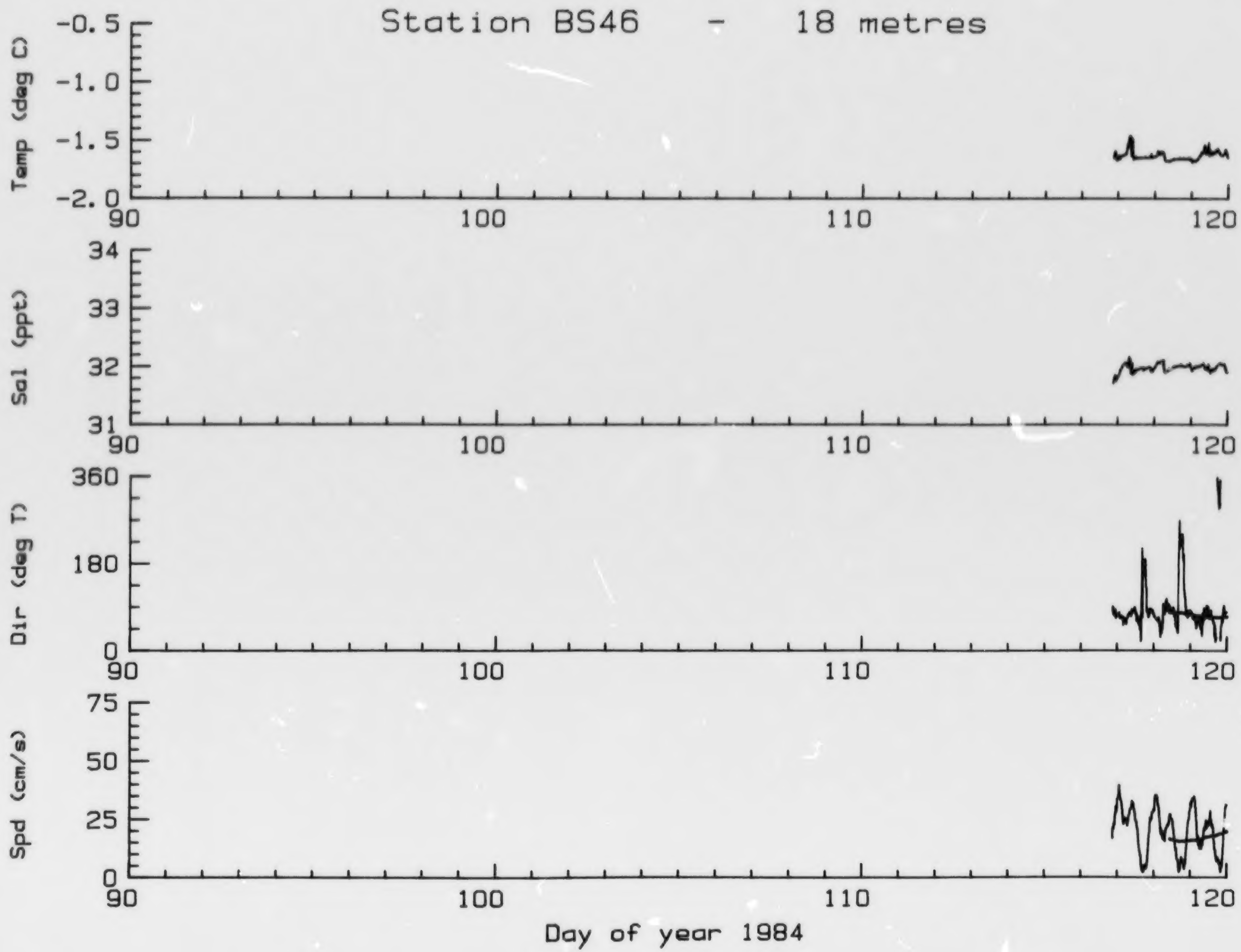

Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
330
340
350
360
Day of year 1984

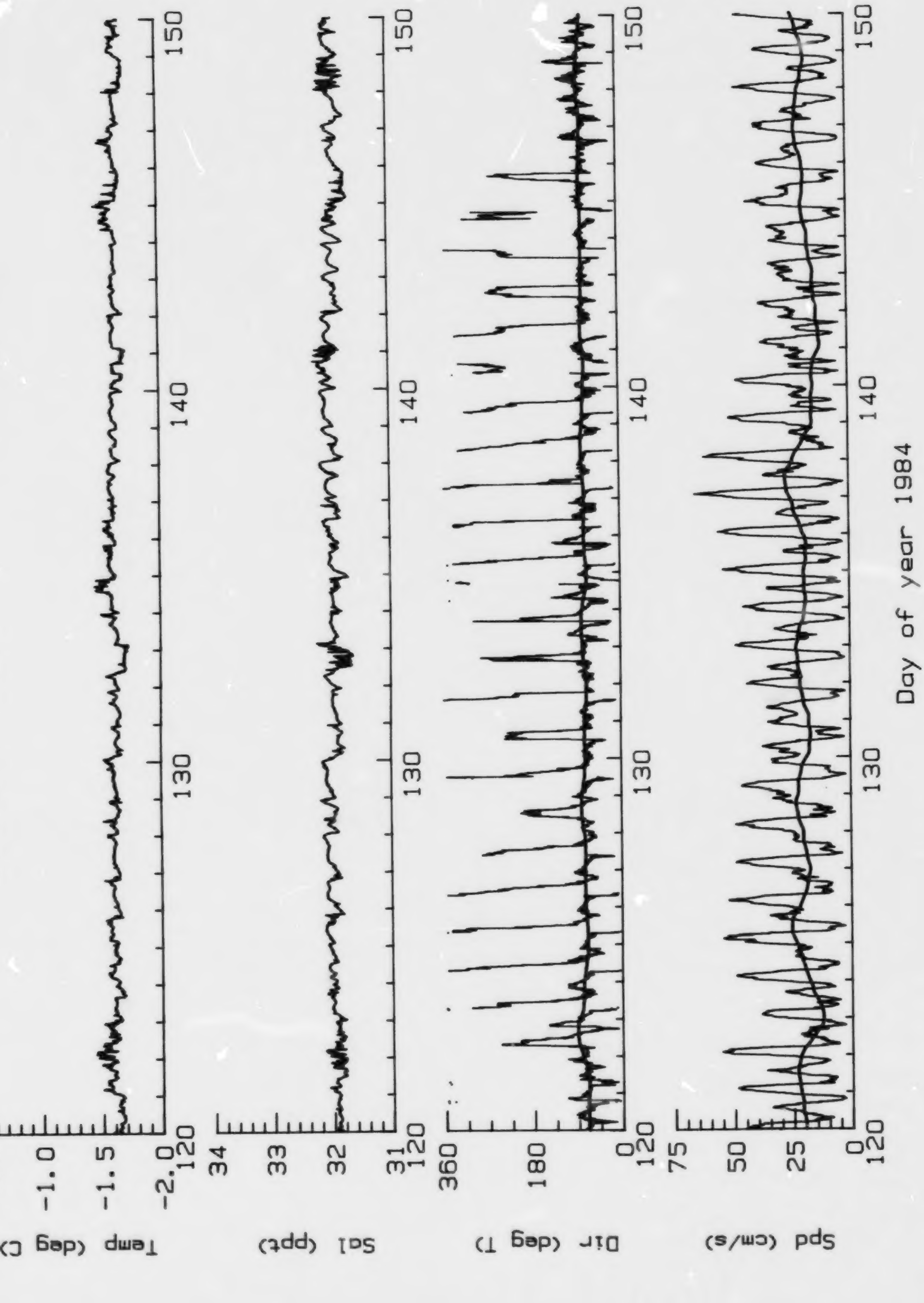

Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
360
10
20
Day of year 1985


Station BS42 - 100 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
30
40
50
Day of year 1985

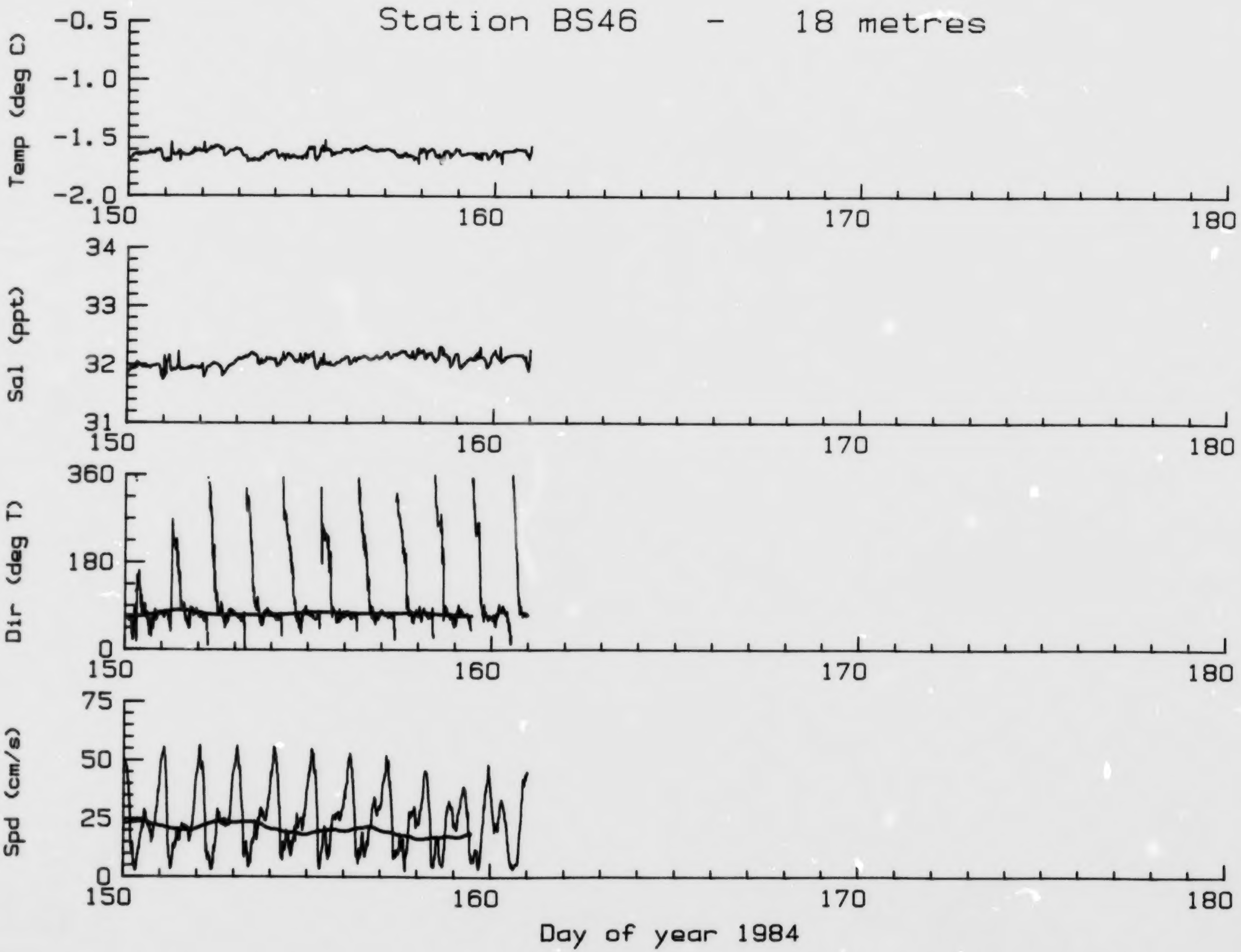
Station BS42 - 100 metres

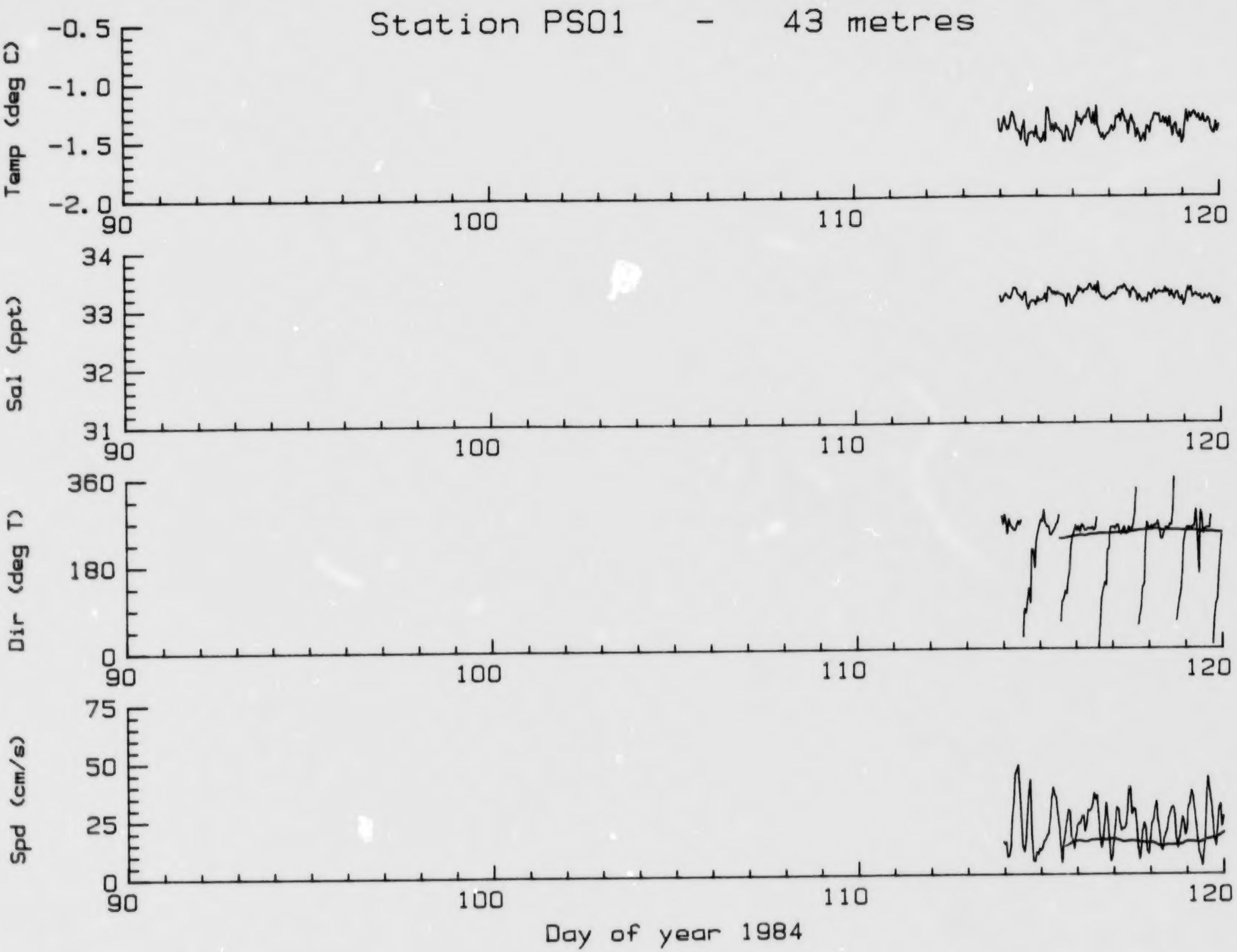


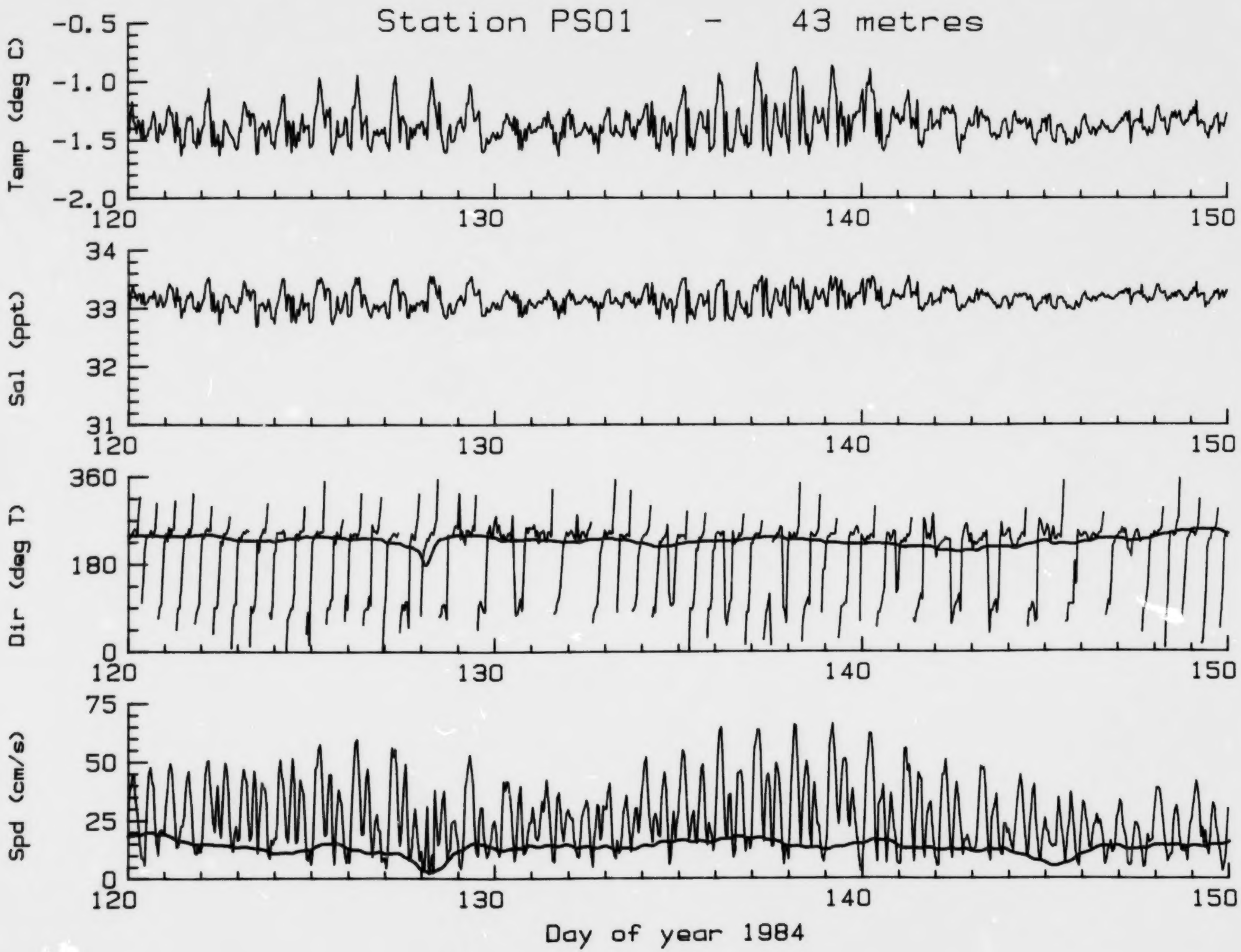

Station BS46 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984

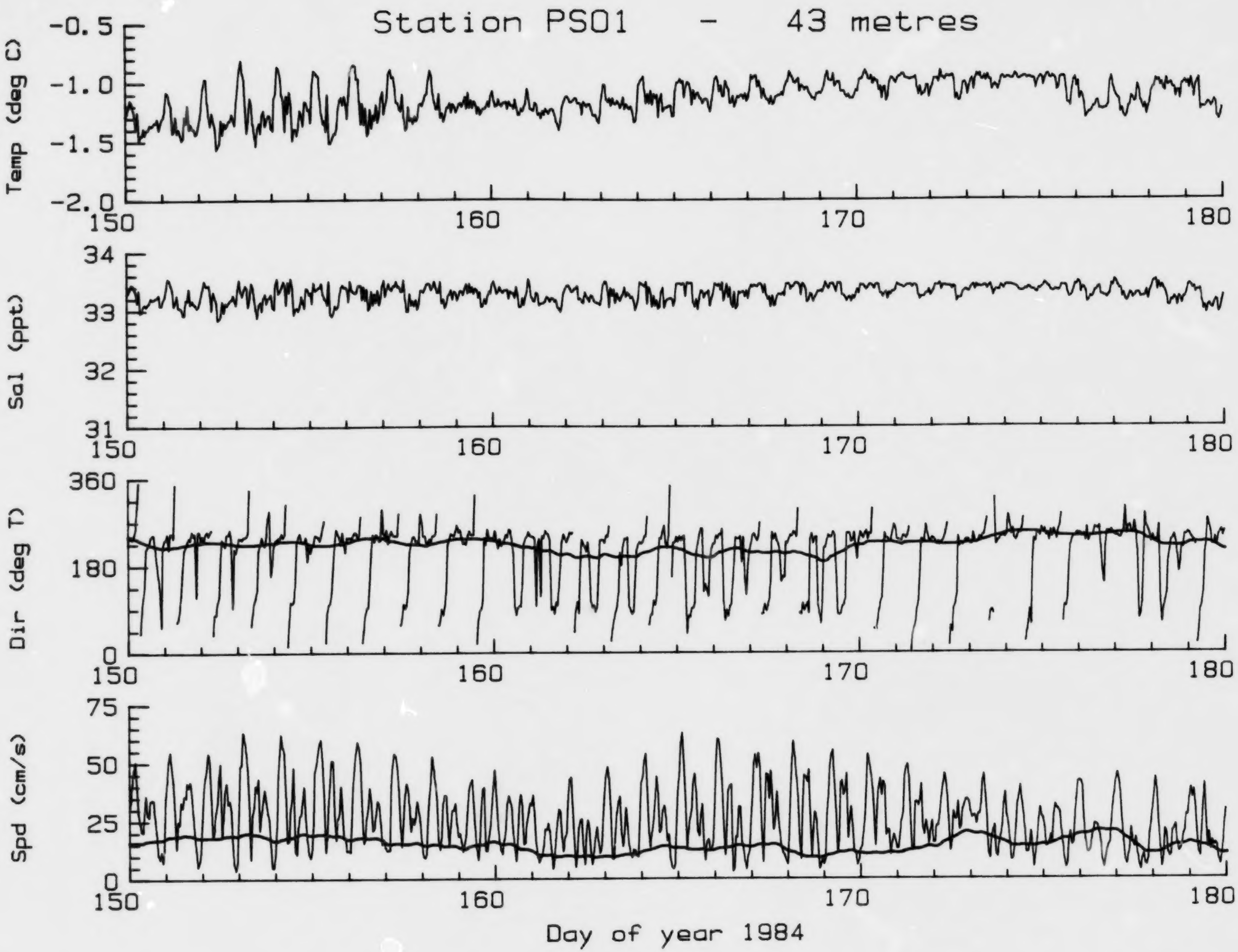


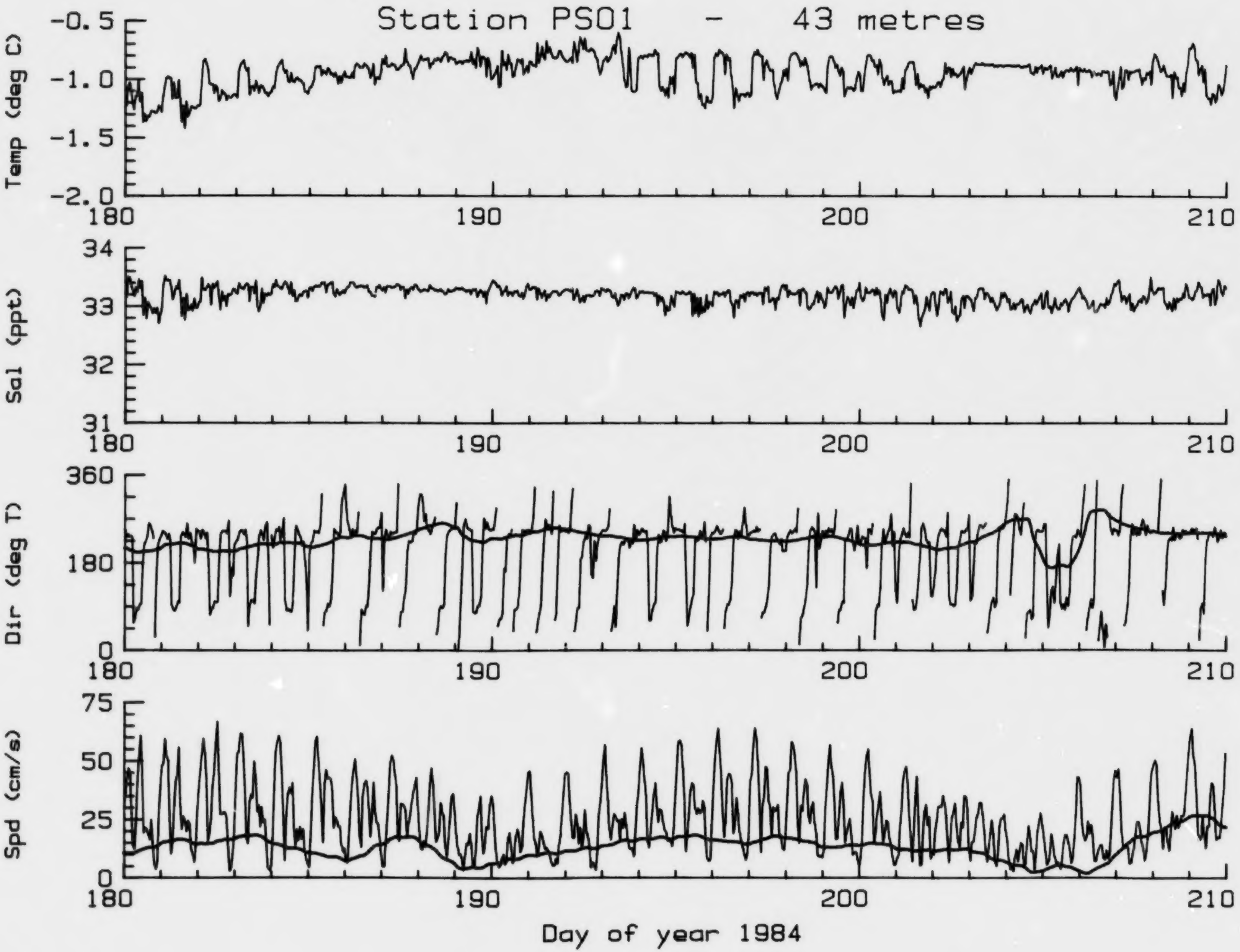
Station BS46 - 18 metres

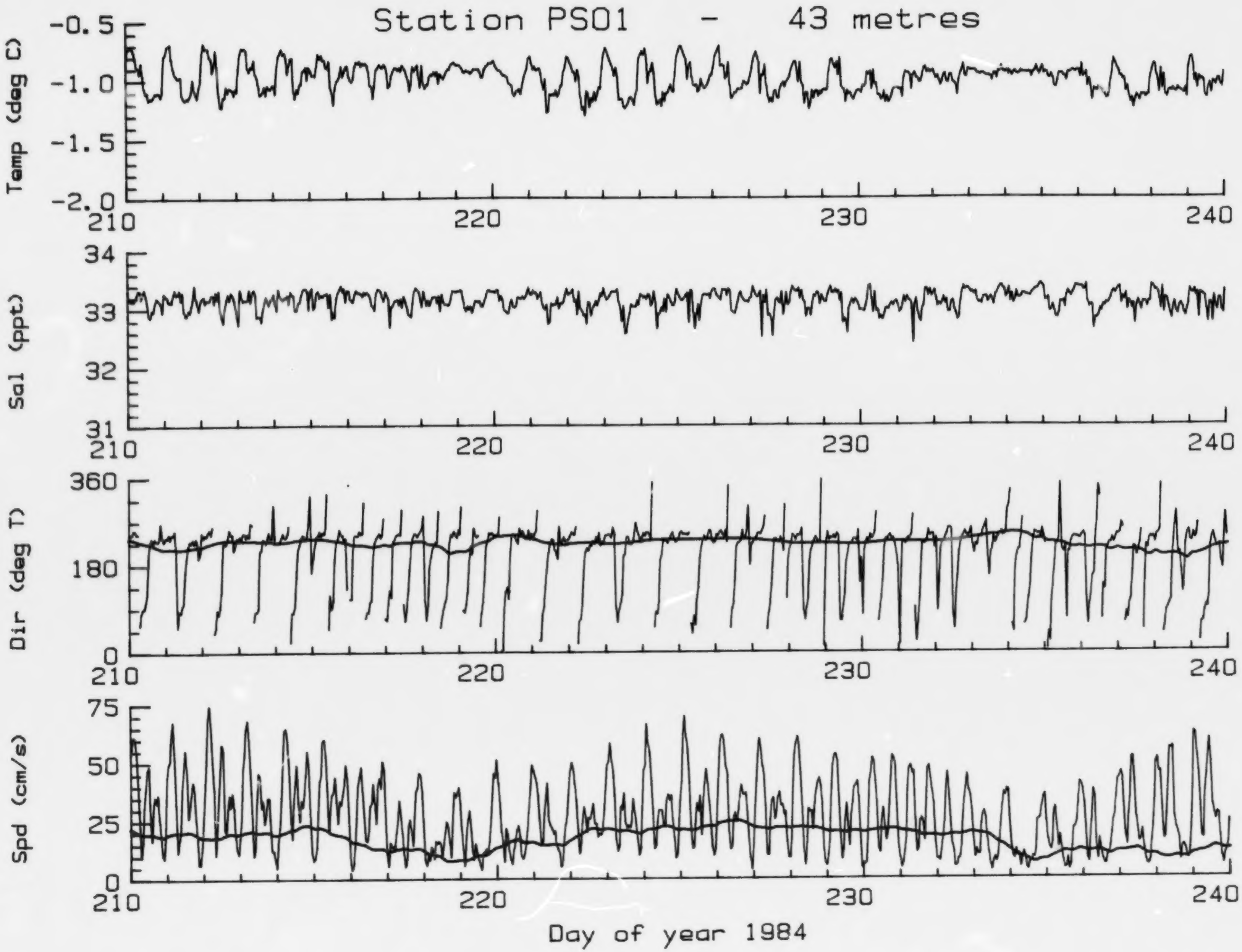

Station BS46 - 18 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

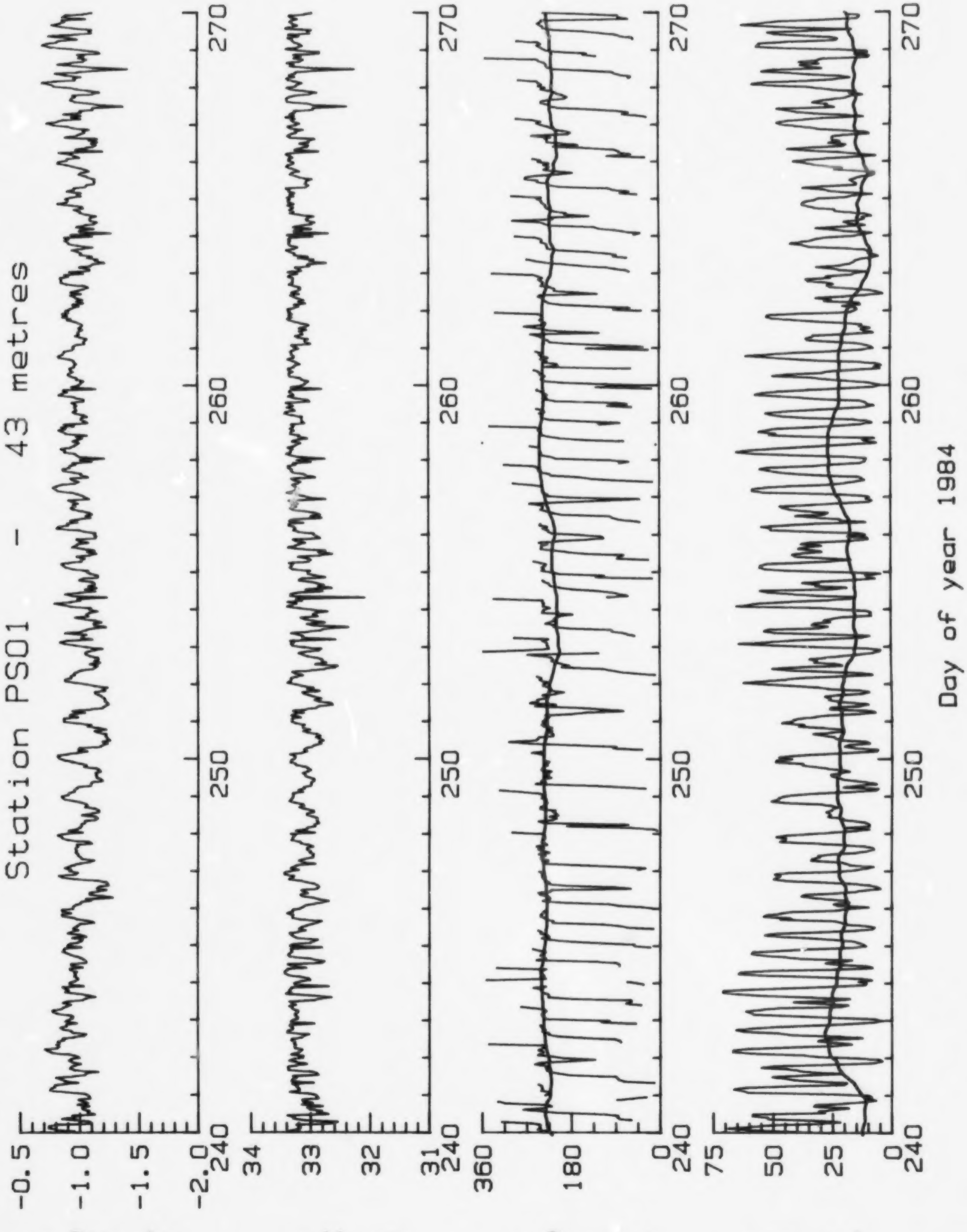

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984

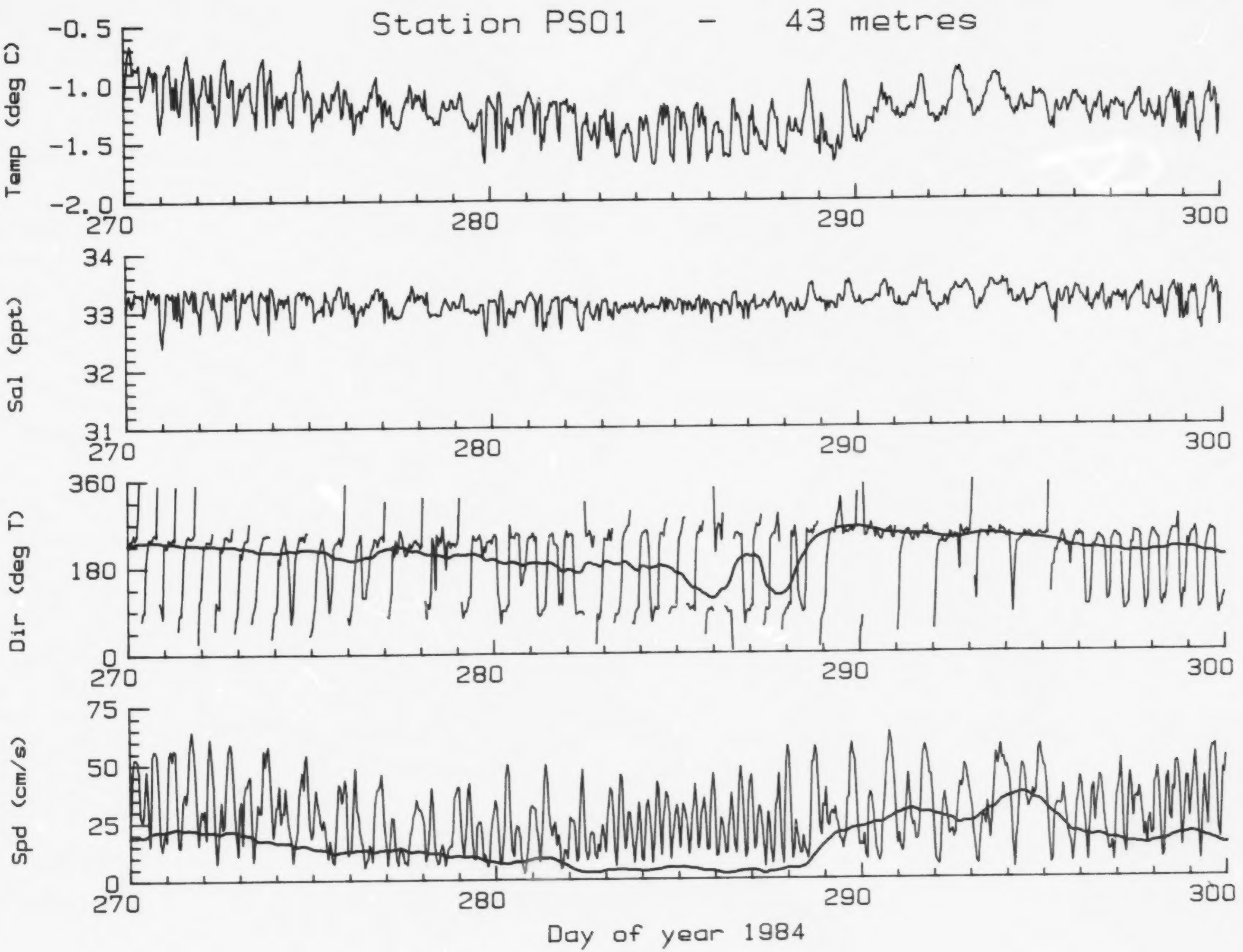

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984

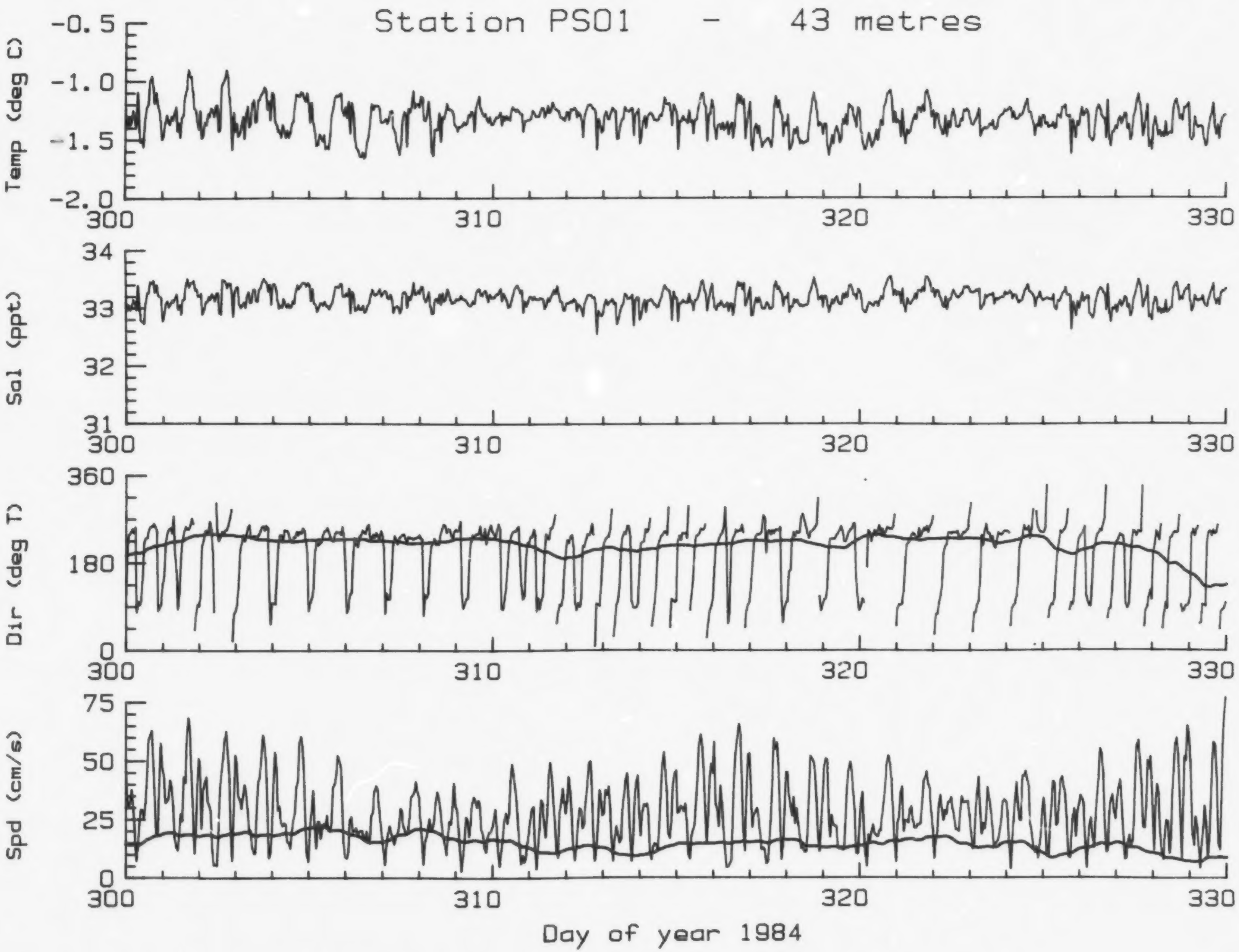

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

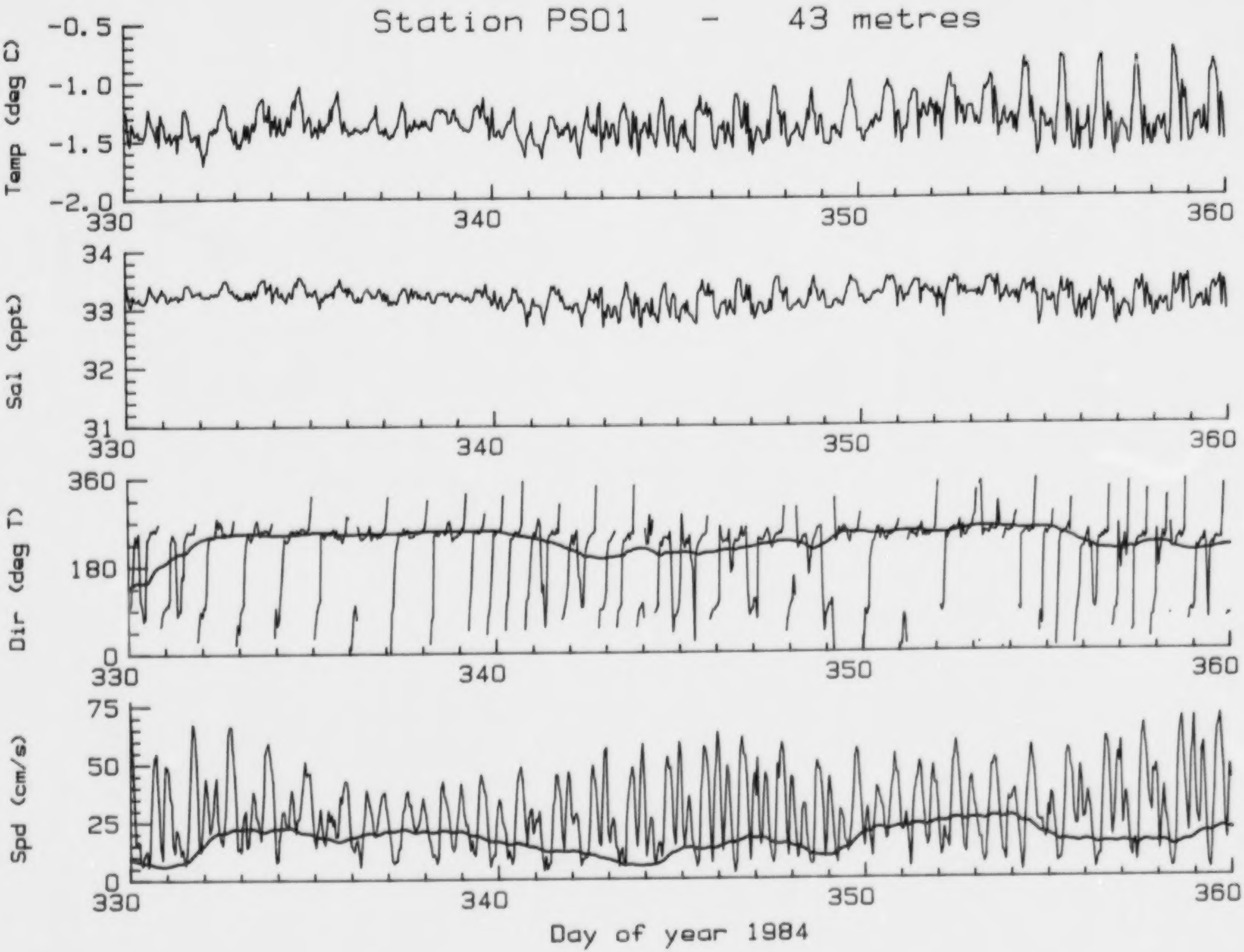

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
180
190
200
210
Day of year 1984

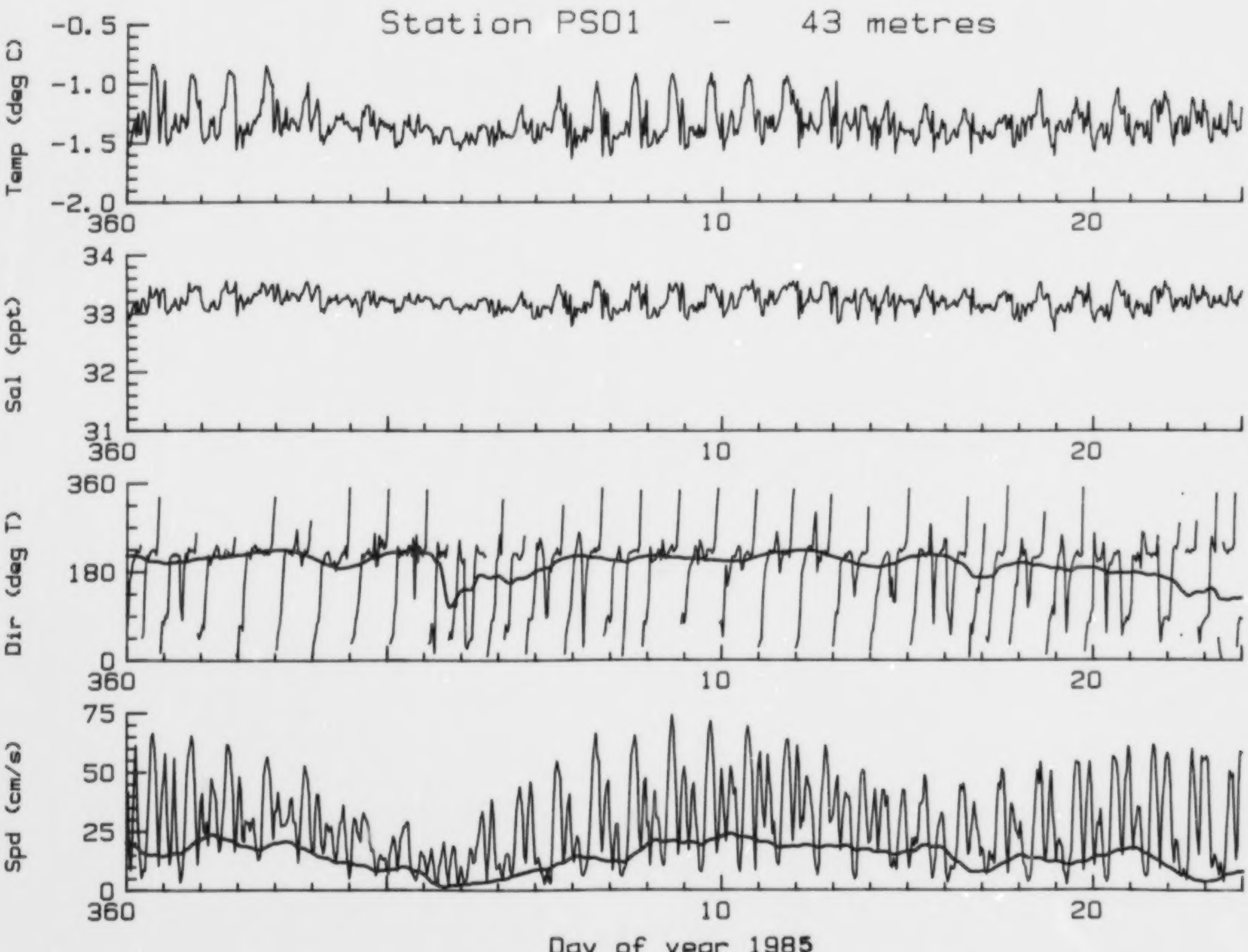

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
210
220
230
240
Day of year 1984

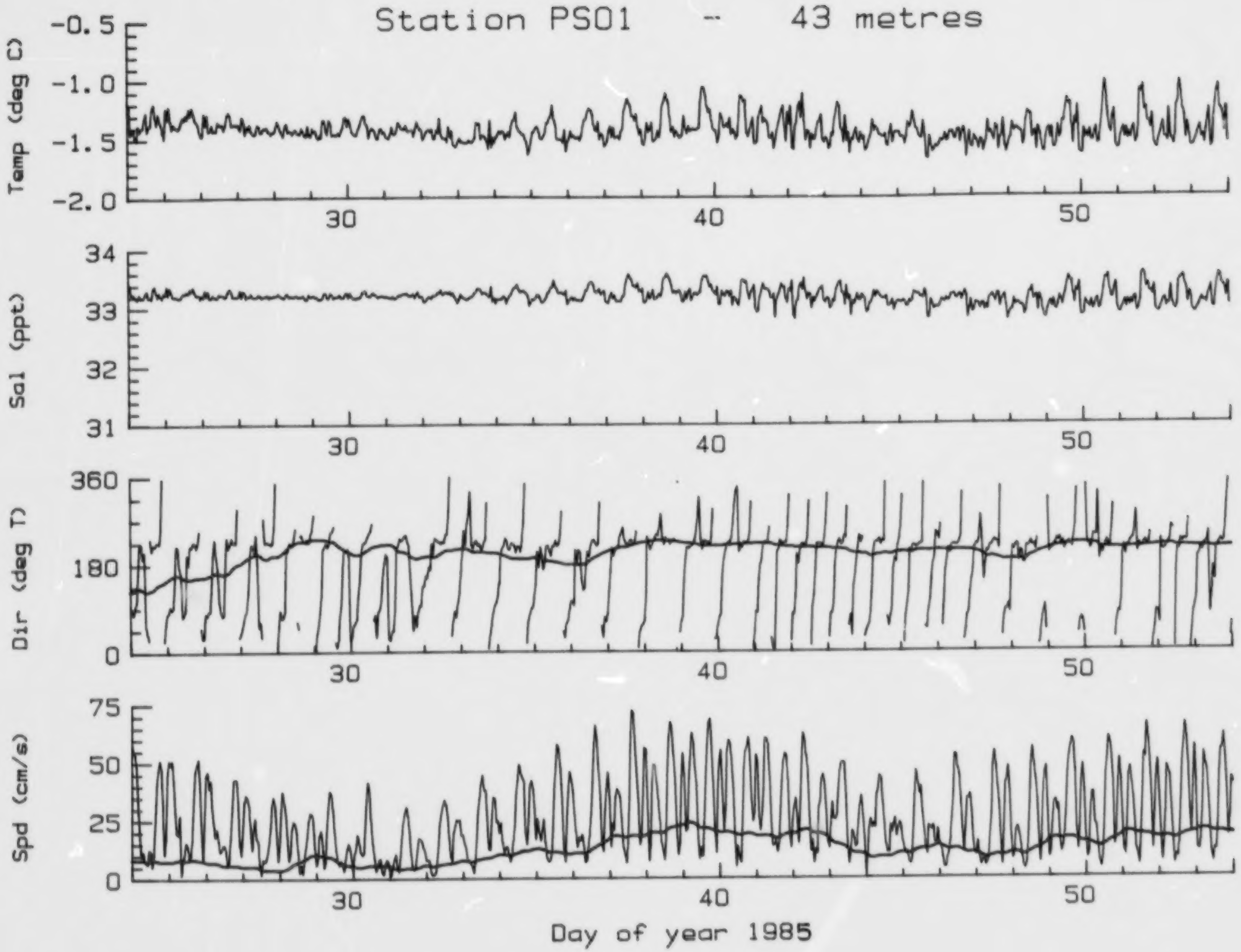

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
240
250
260
270
Day of year 1984

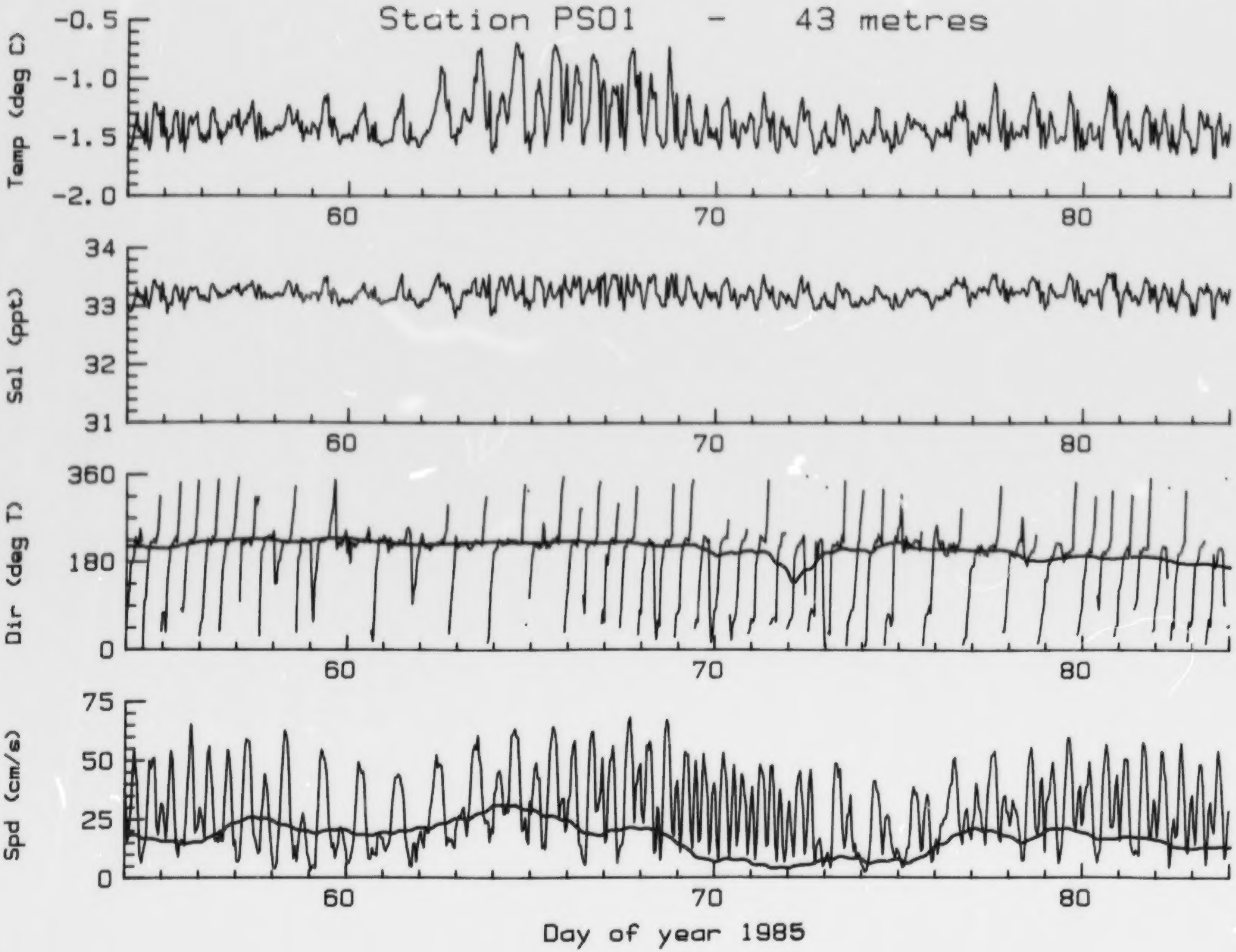

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
270
280
290
300
Day of year 1984

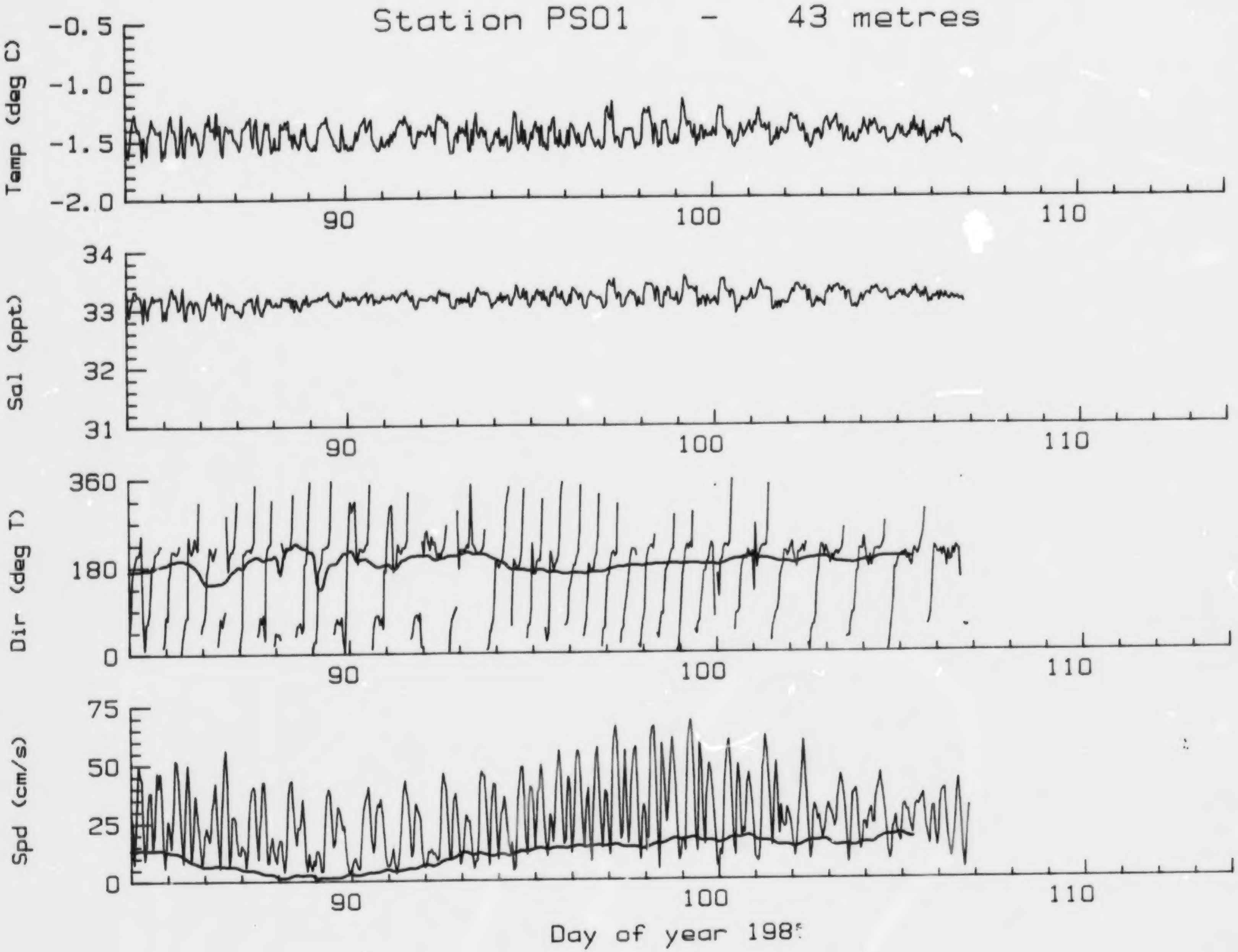

Station PS01 - 43 metres

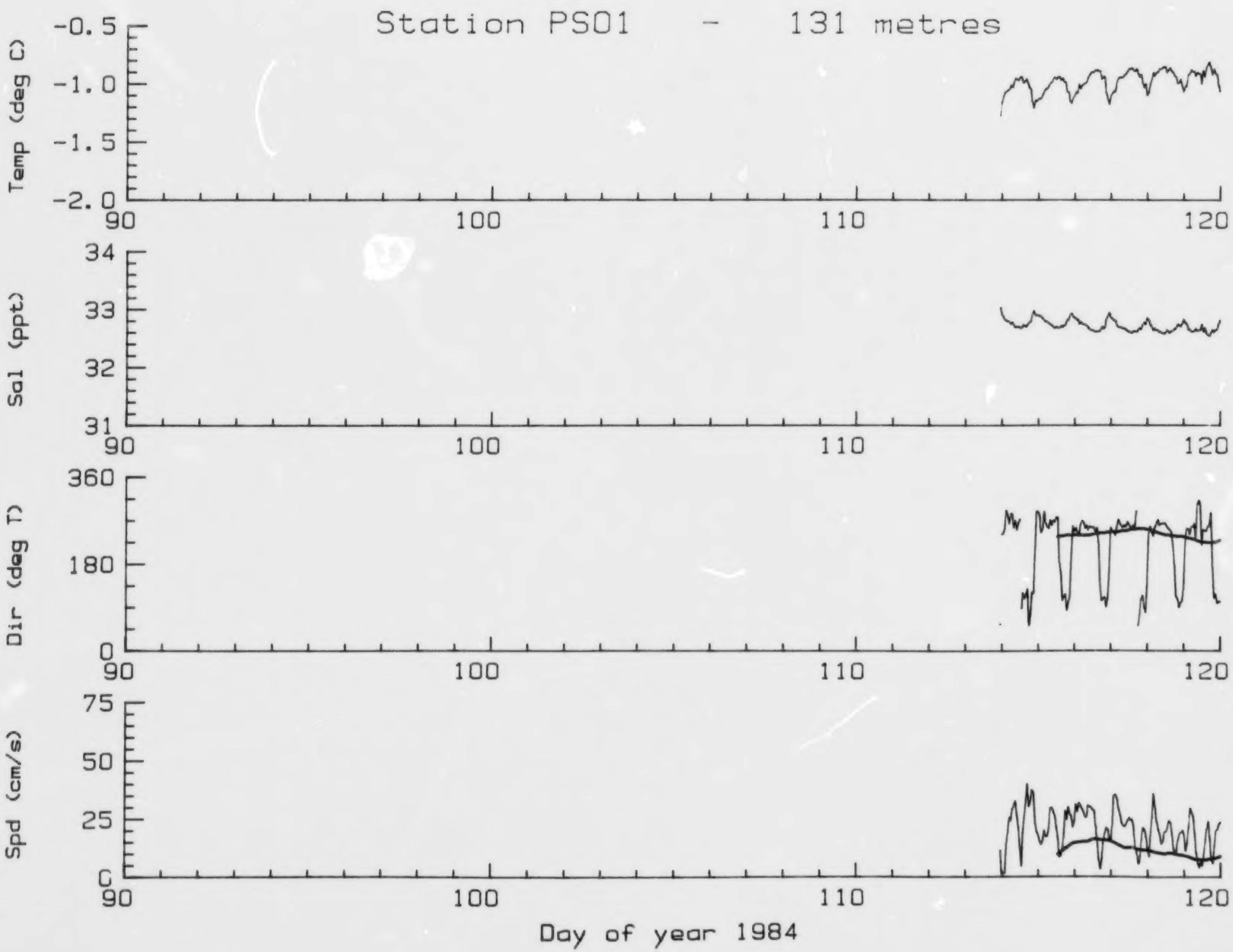

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
330
340
350
360
Day of year 1984

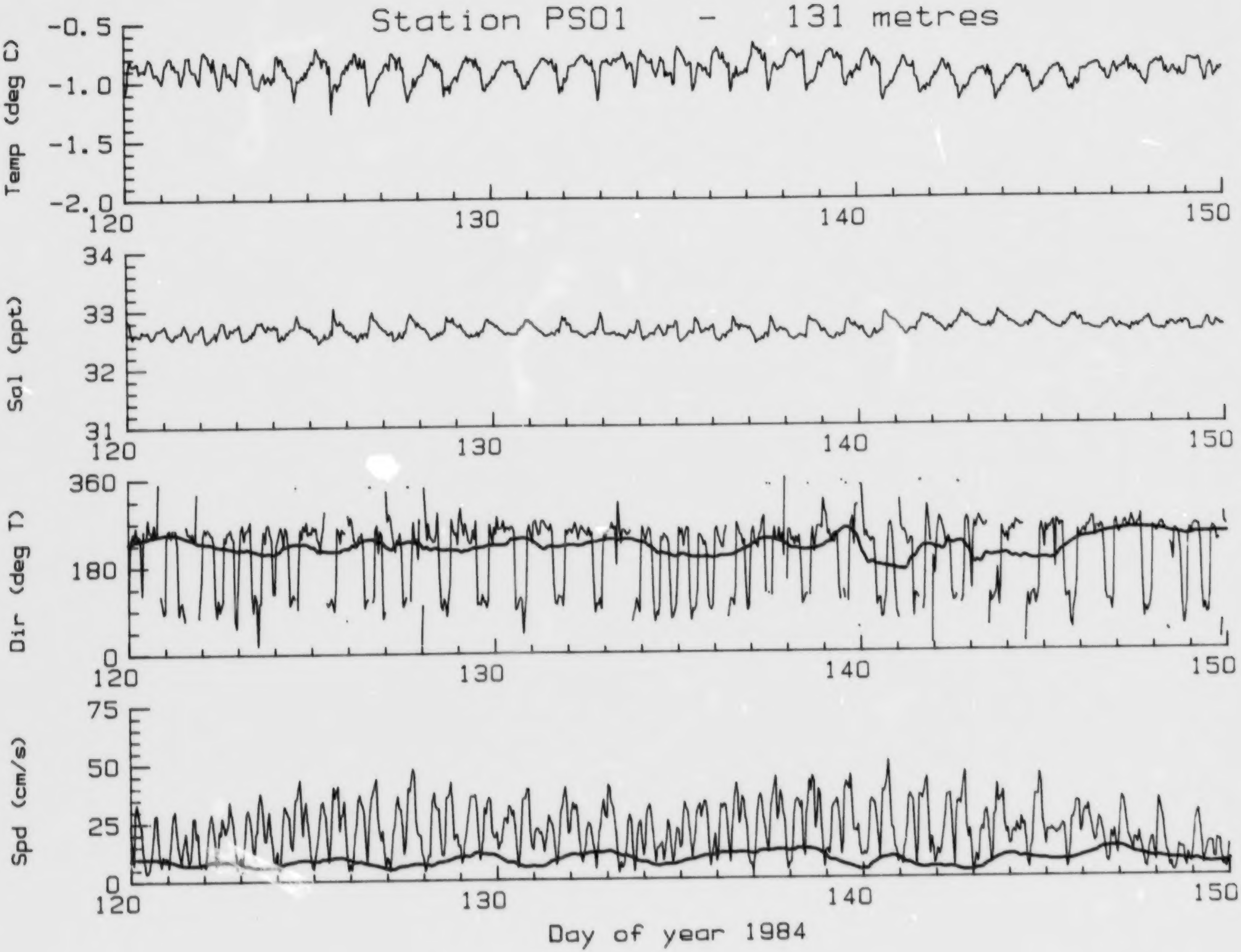

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
360
10
20
Day of year 1985

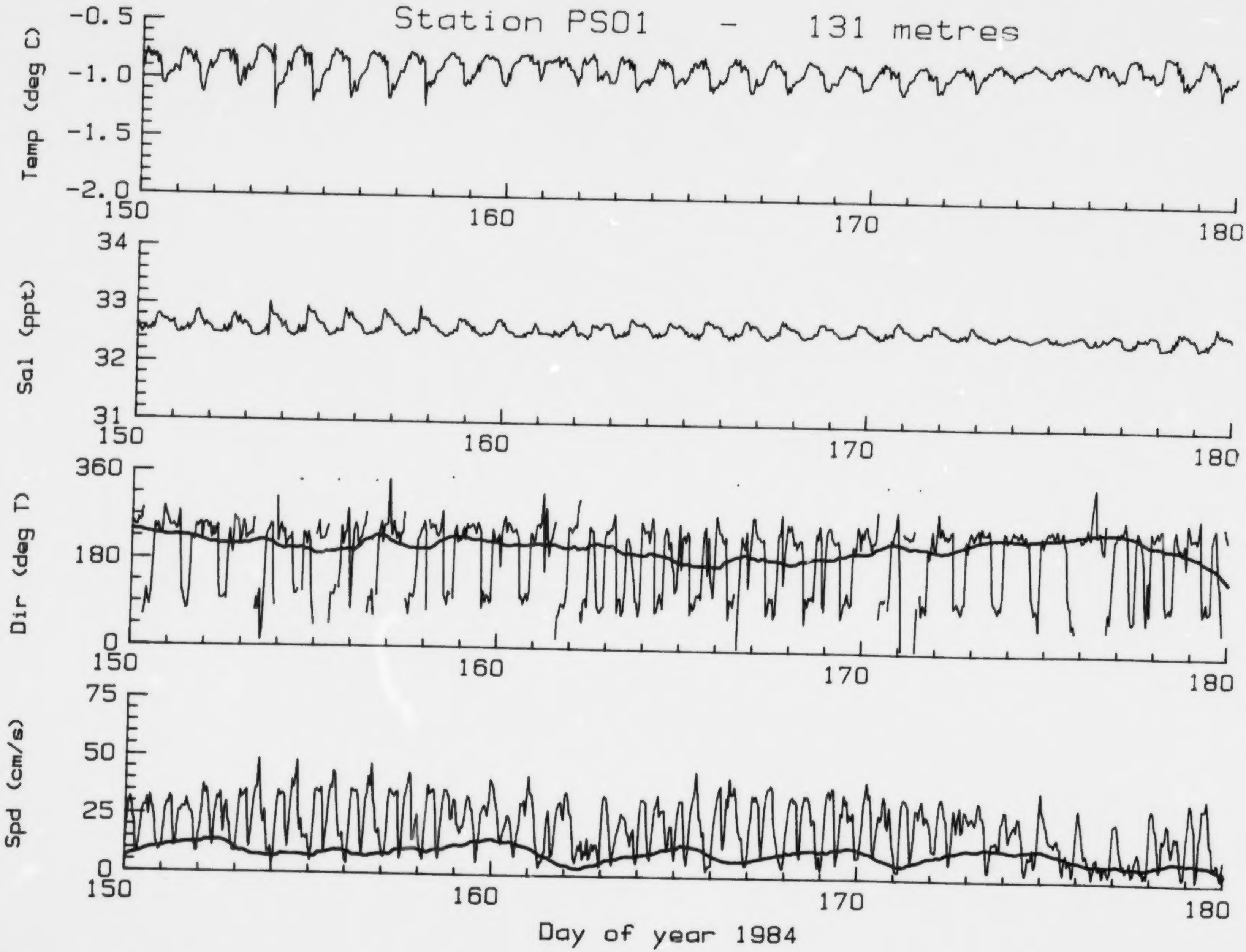

Station PS01 – 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
30
40
50
Day of year 1985

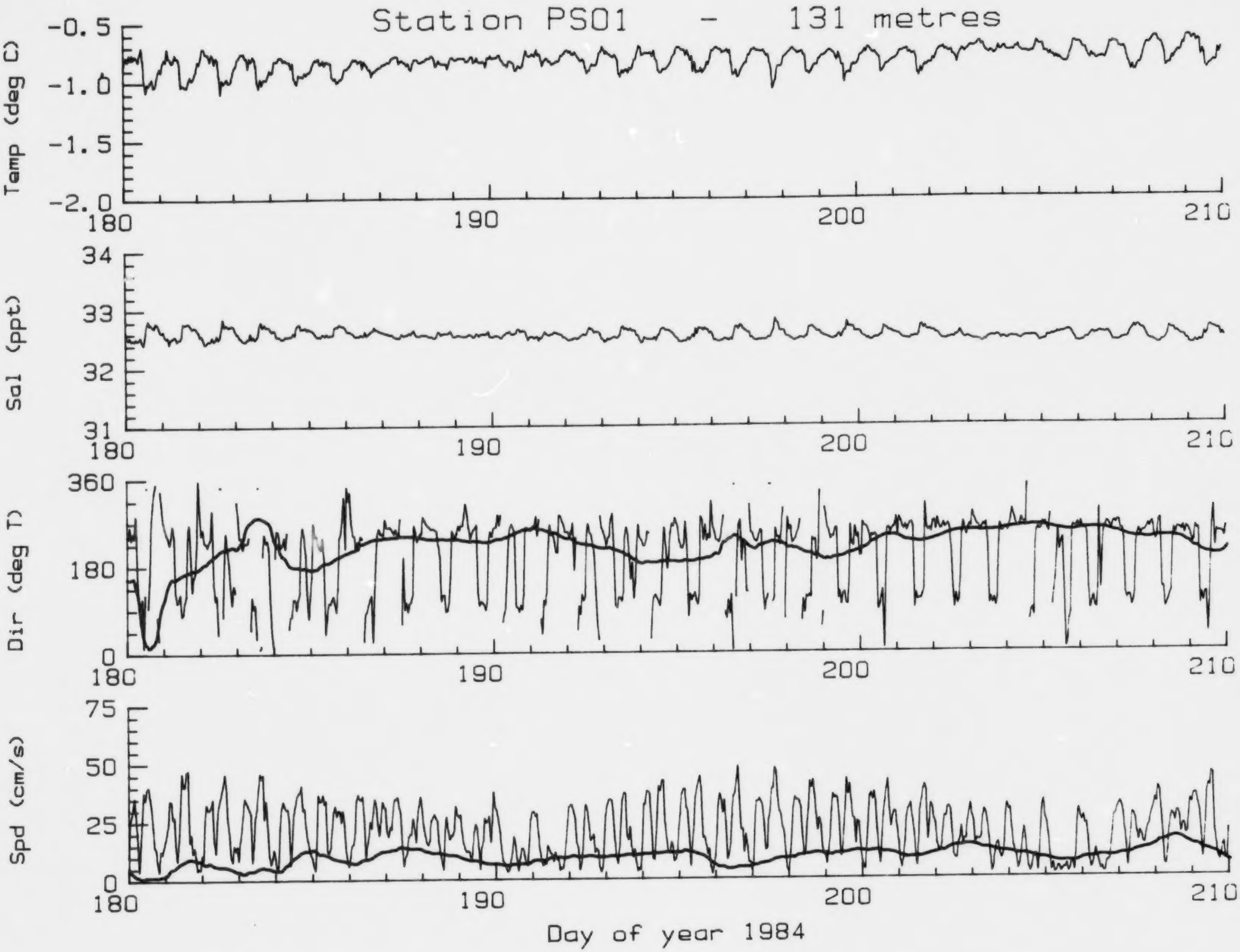

Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
60
70
80
Day of year 1985


Station PS01 - 43 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
Day of year 198

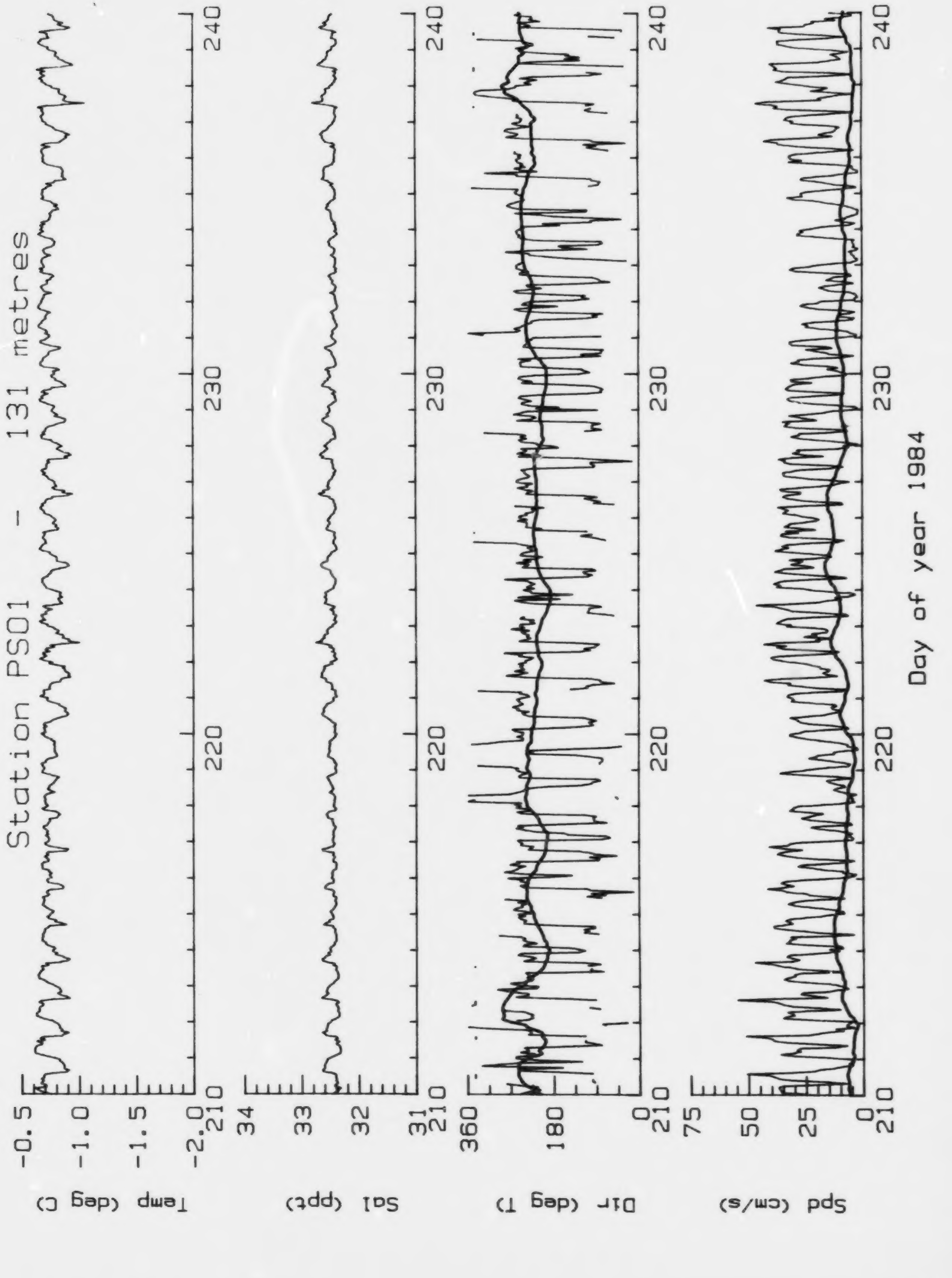

Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984

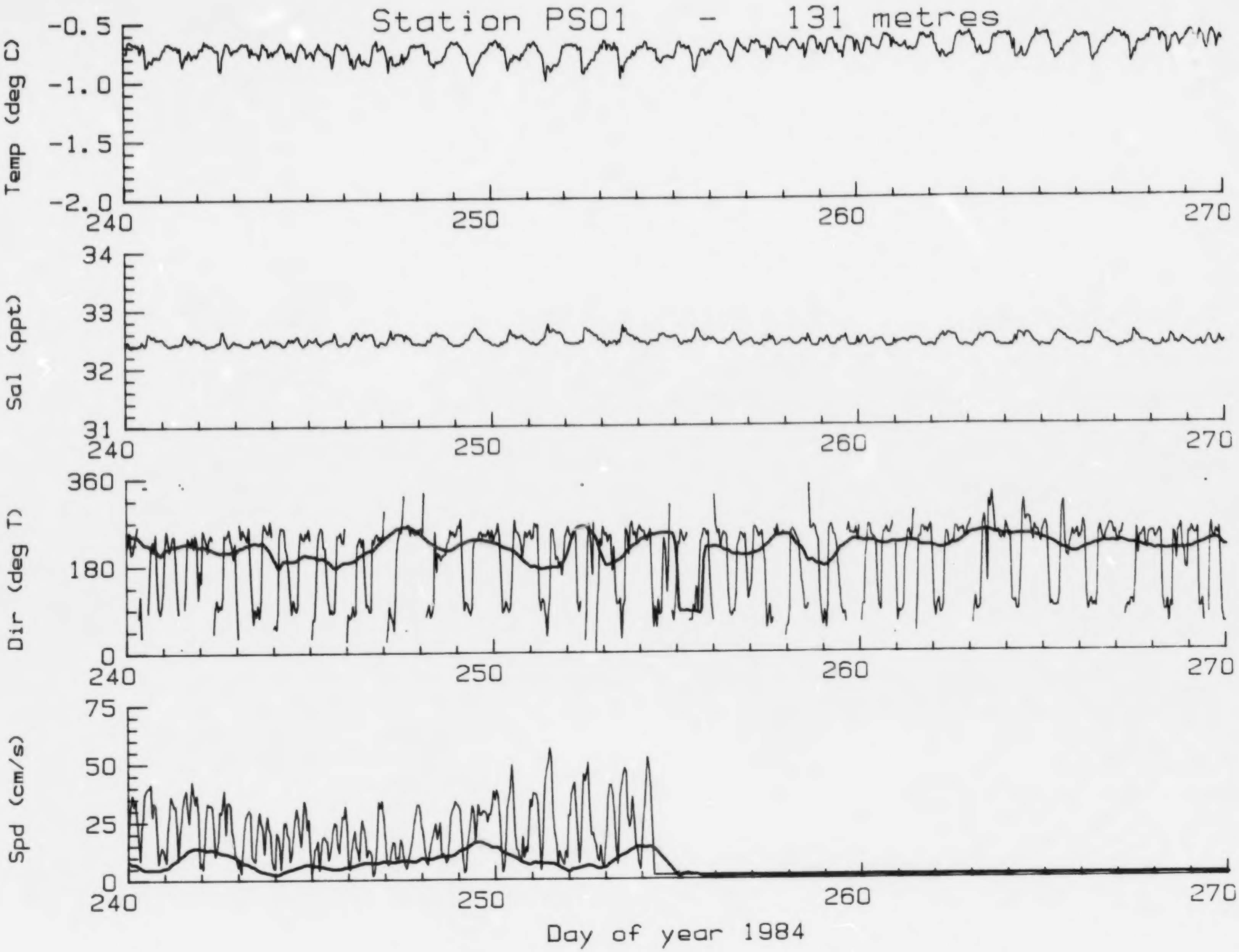

Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984

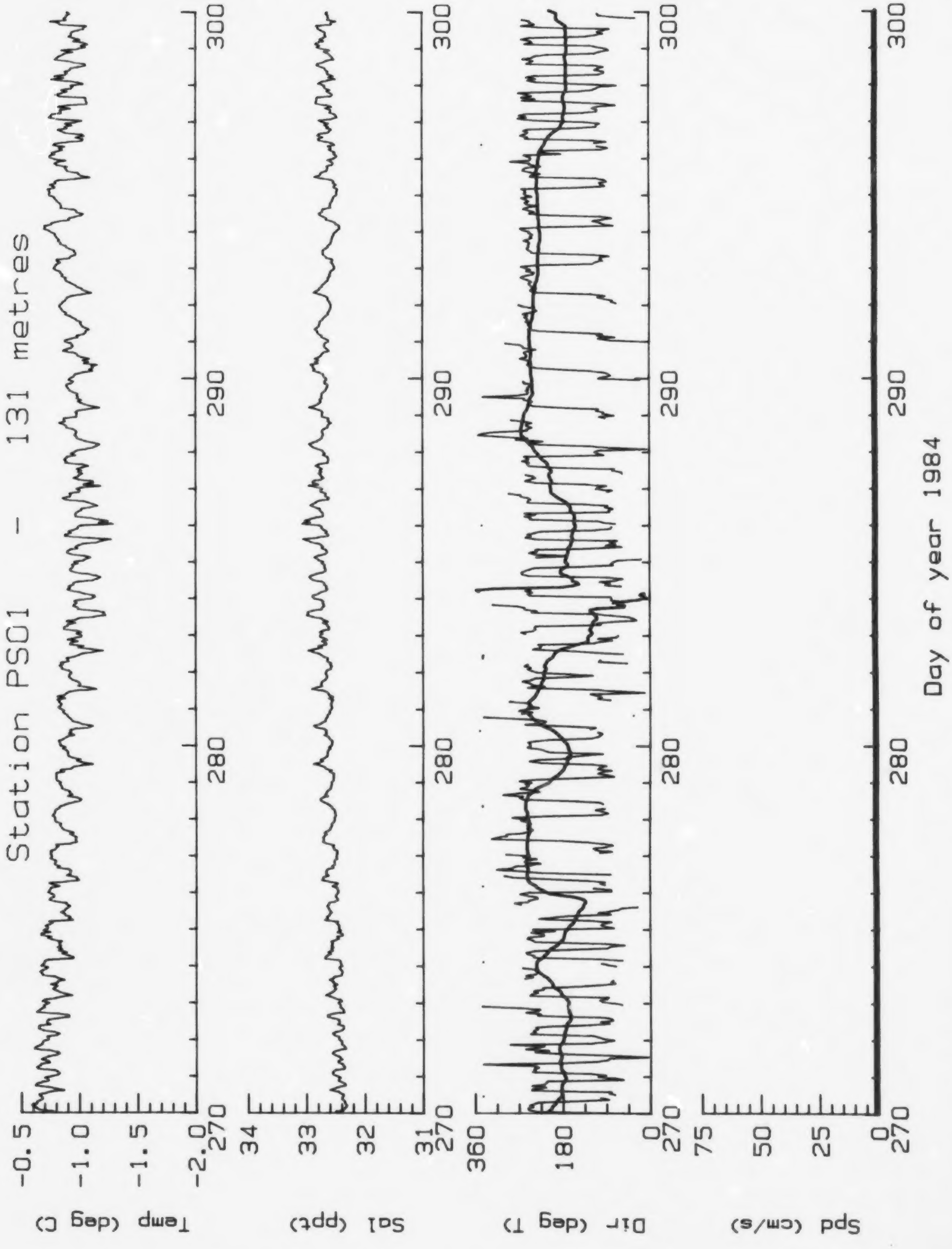

Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

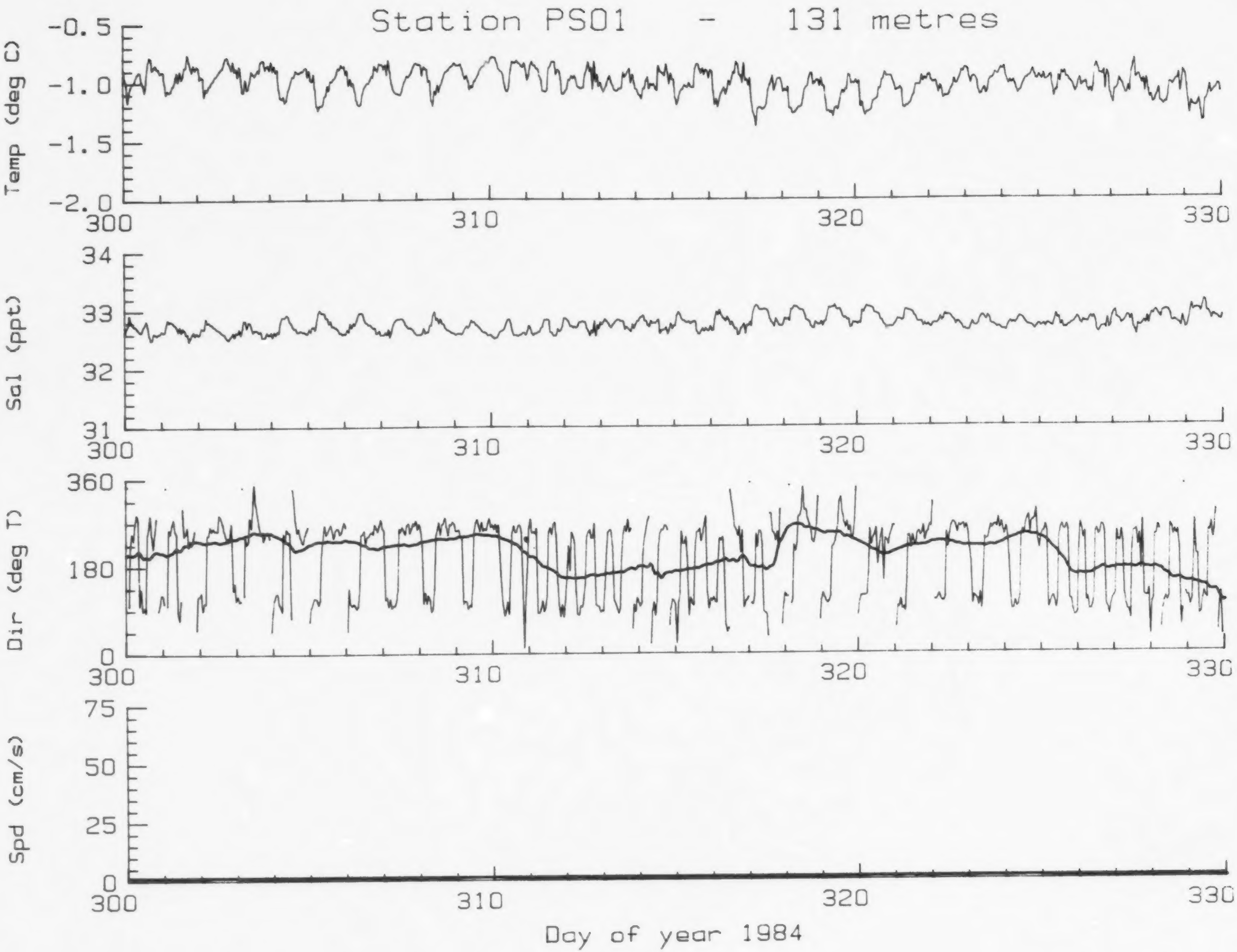


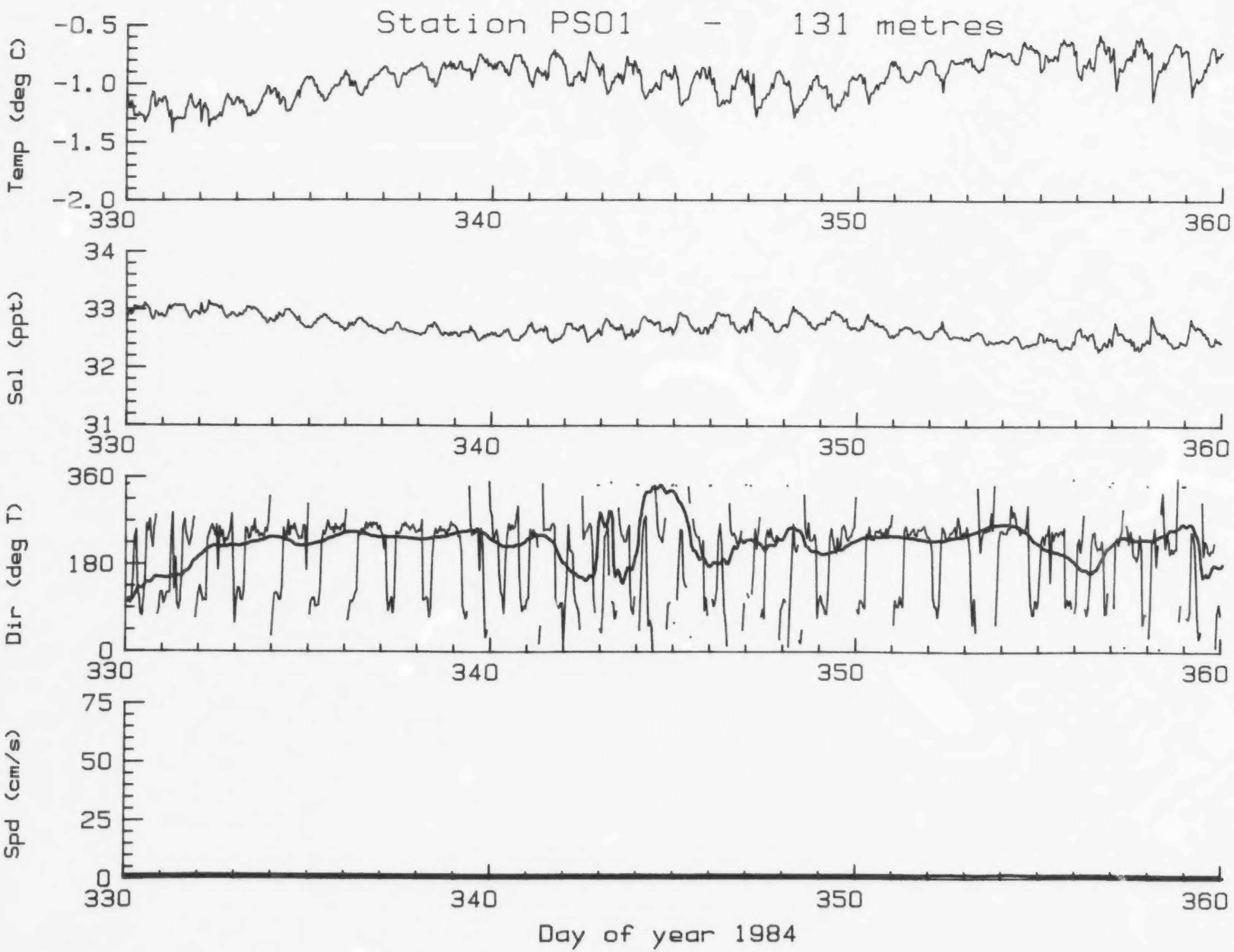
Station PS01 - 131 metres


Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
210
220
230
240
Day of year 1984

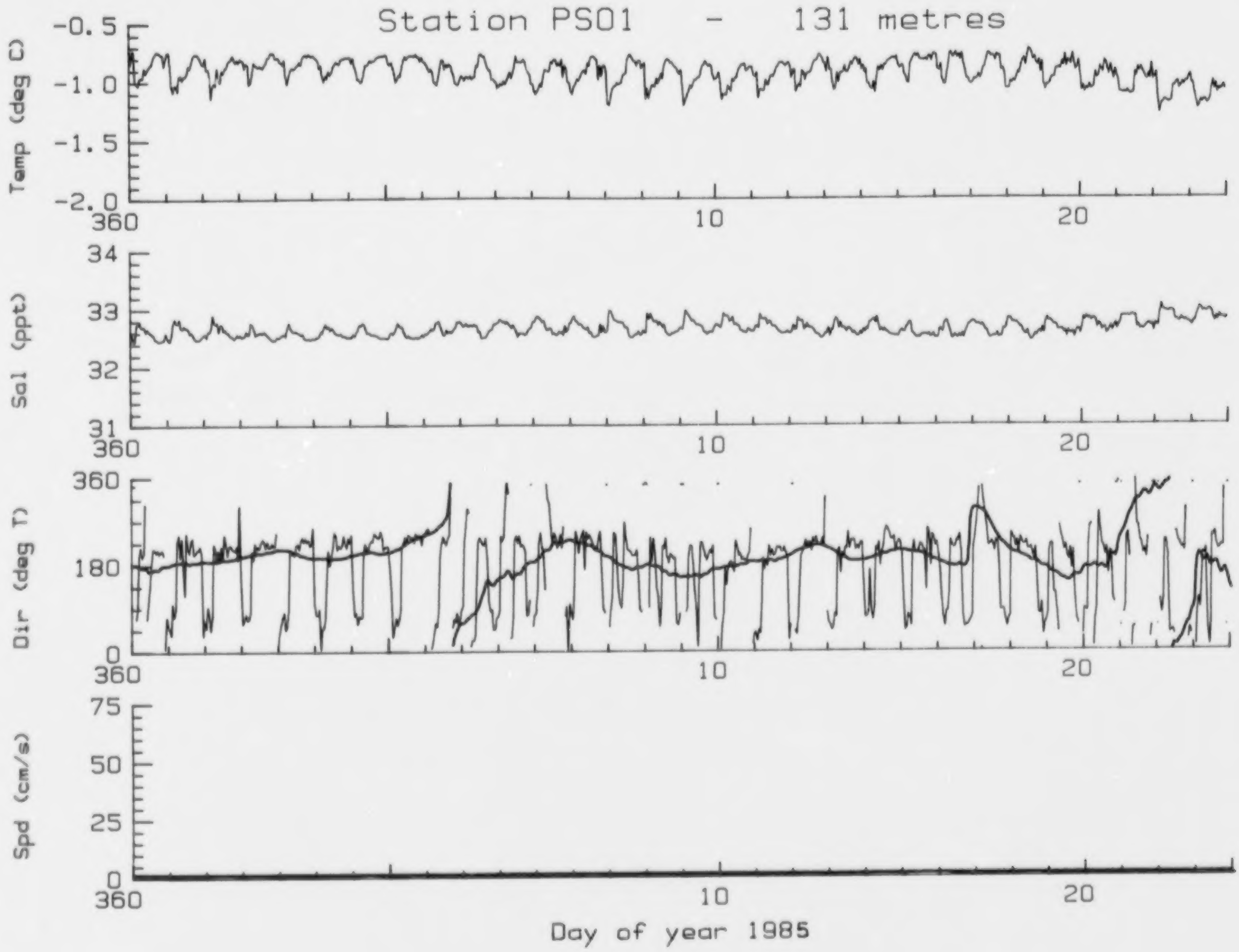

Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
240
250
260
270
Day of year 1984

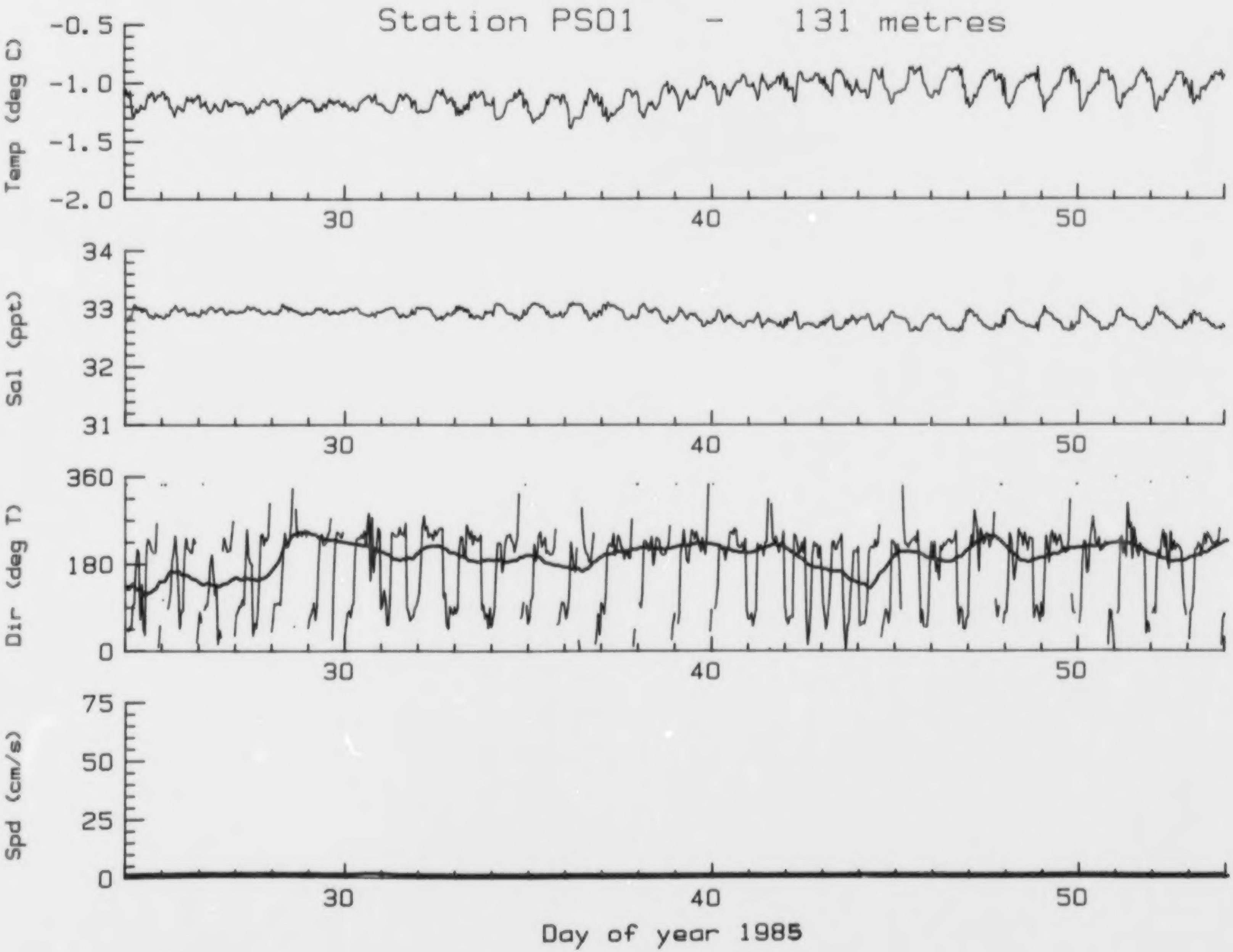

Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
270
280
290
300
Day of year 1984


Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
300
310
320
330
Day of year 1984



Station PS01 - 131 metres


Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
360
10
20
Day of year 1985


Station PS01 - 131 metres
Temp (deg C)
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-1.5
-2.0
Sal (ppt)
34
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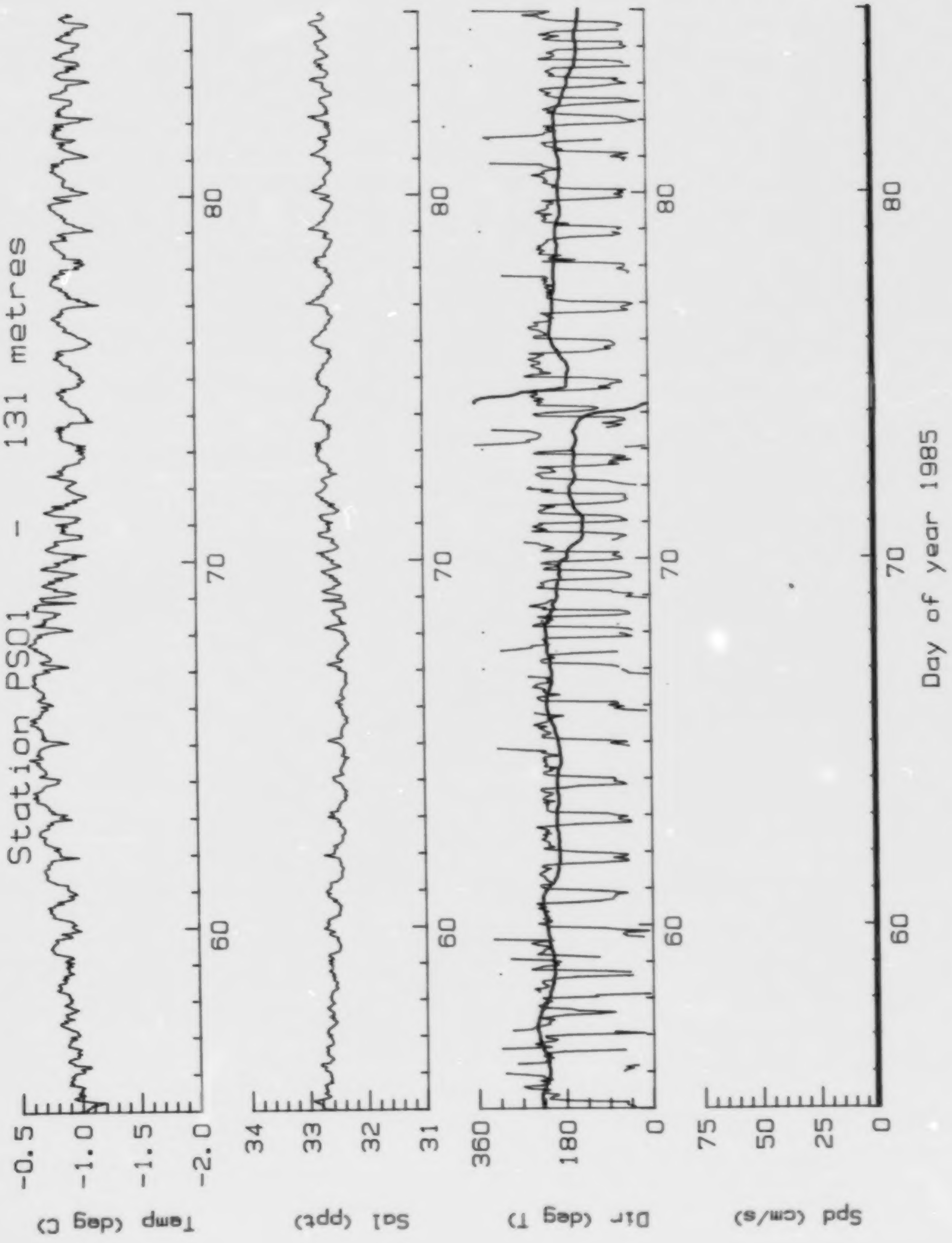
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
30
40
50
Day of year 1985


Station PS01 - 131 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
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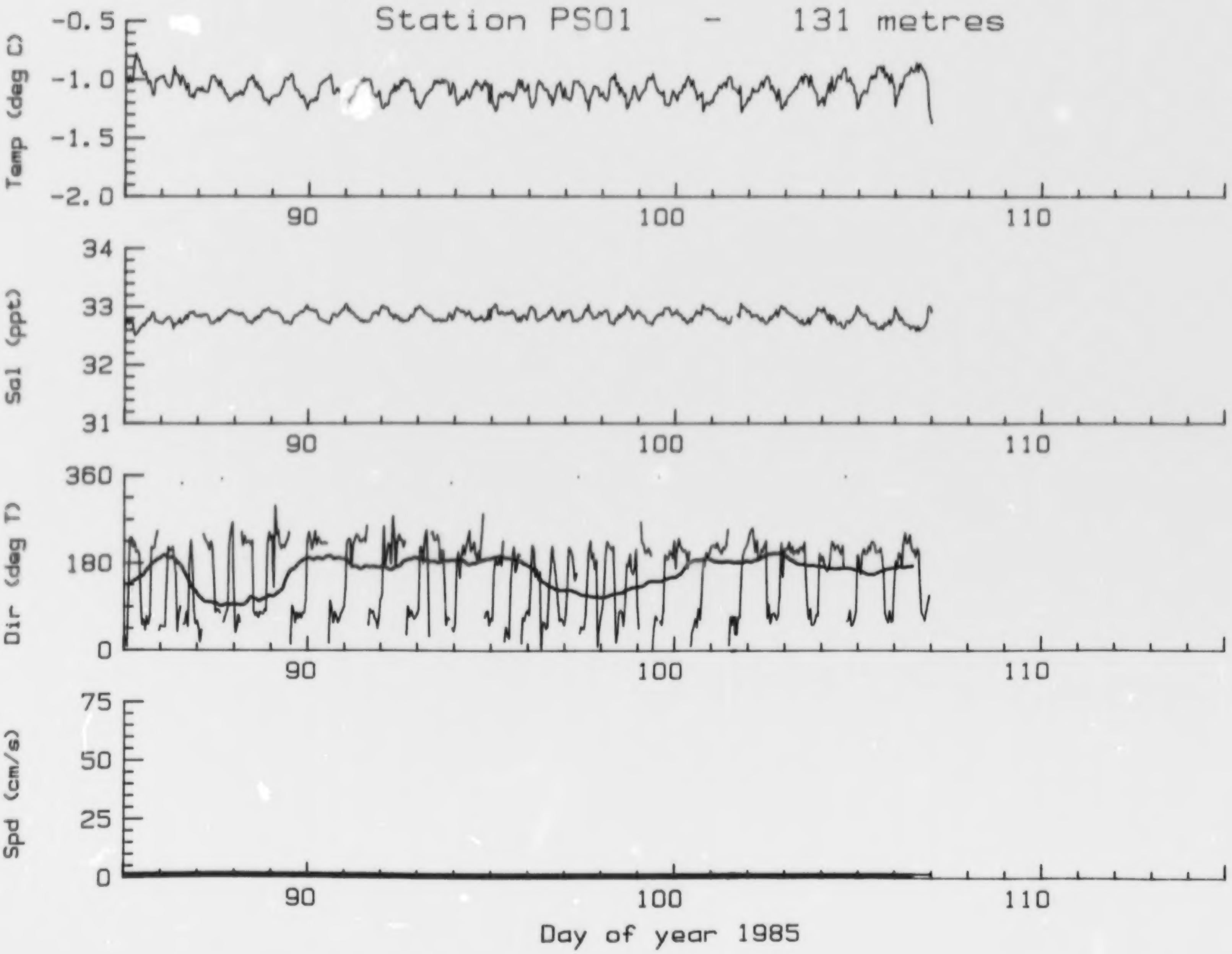
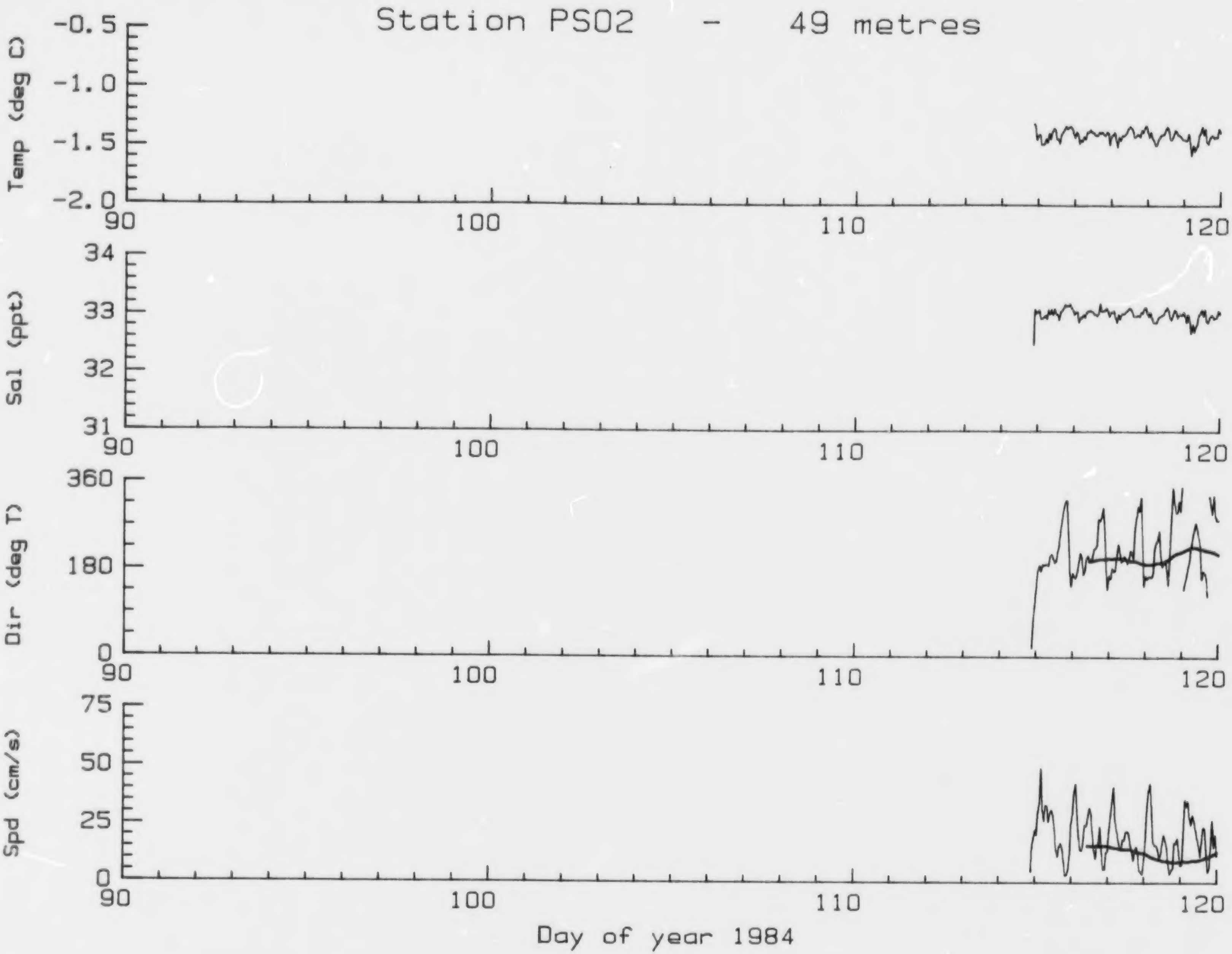
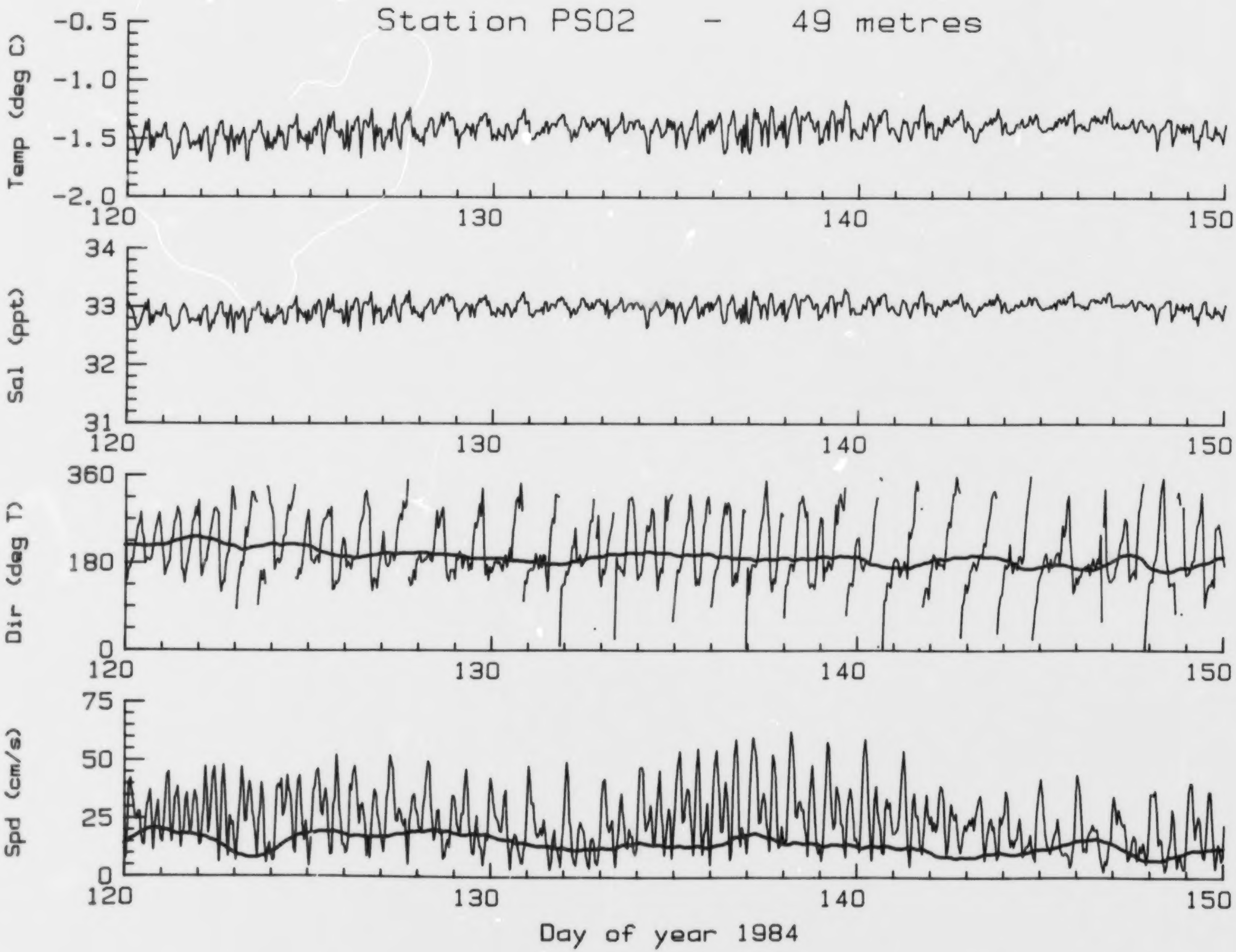
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
60
70
80
Day of year 1985



Station PS01 - 131 metres


Station PS02 - 49 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
120
Day of year 1984


Station PS02 - 49 metres
Temp (deg C)
-0.5
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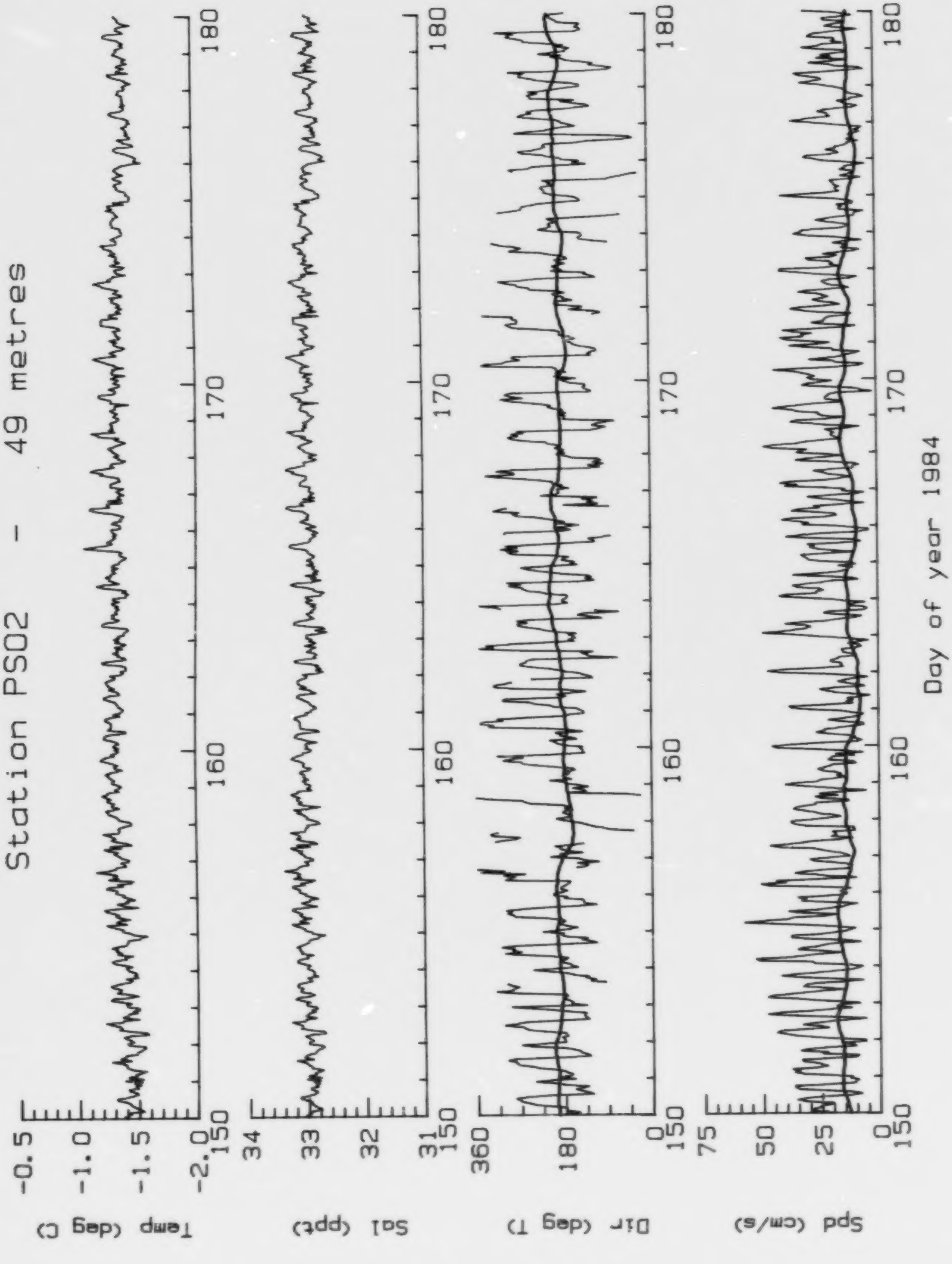
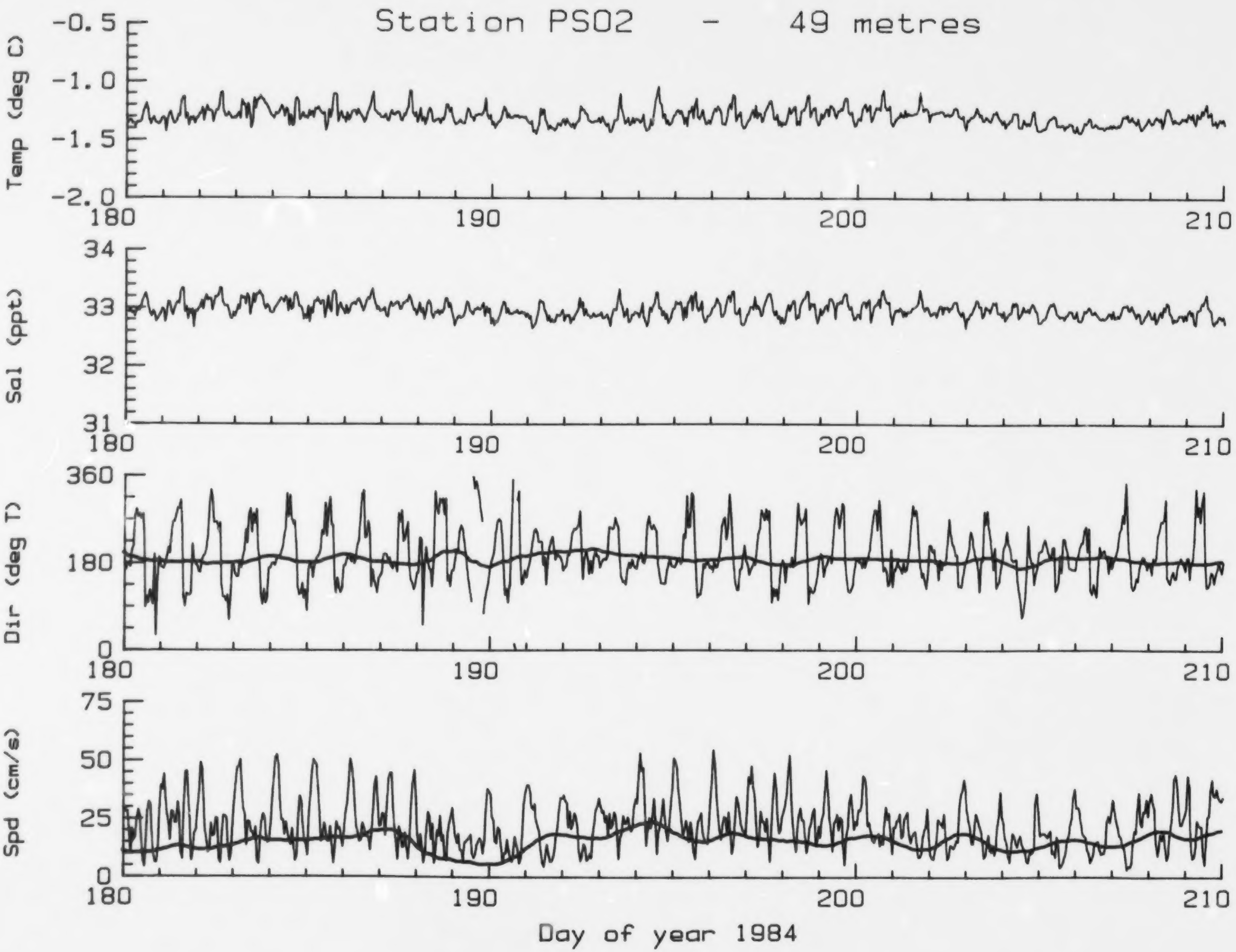
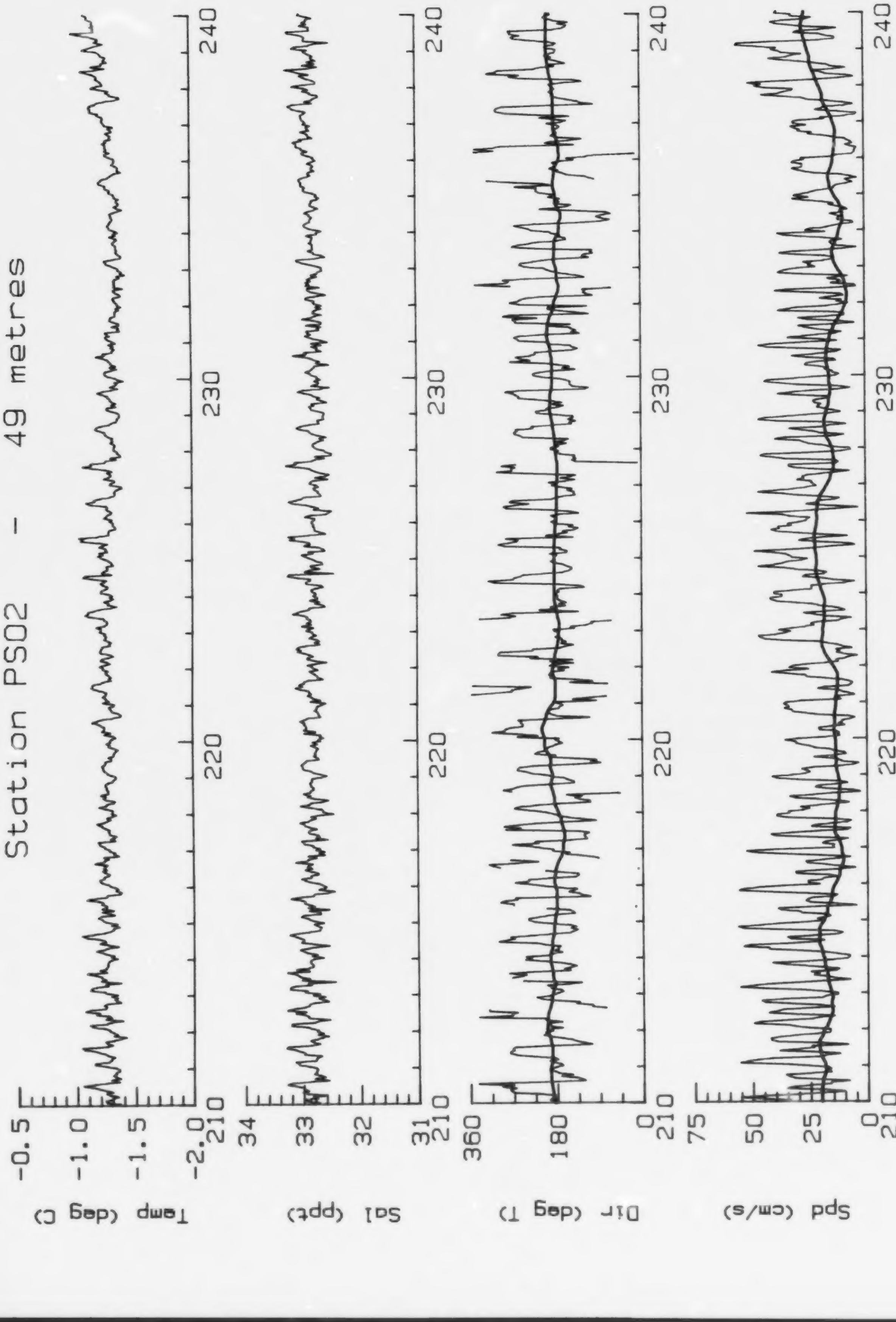
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
120
130
140
150
Day of year 1984


Station PS02 - 49 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984


Station PS02 - 49 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
180
190
200
210
Day of year 1984


Station PS02 - 49 metres
Temp (deg C)
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-1.0
-1.5
-2.0
Sal (ppt)
34
33
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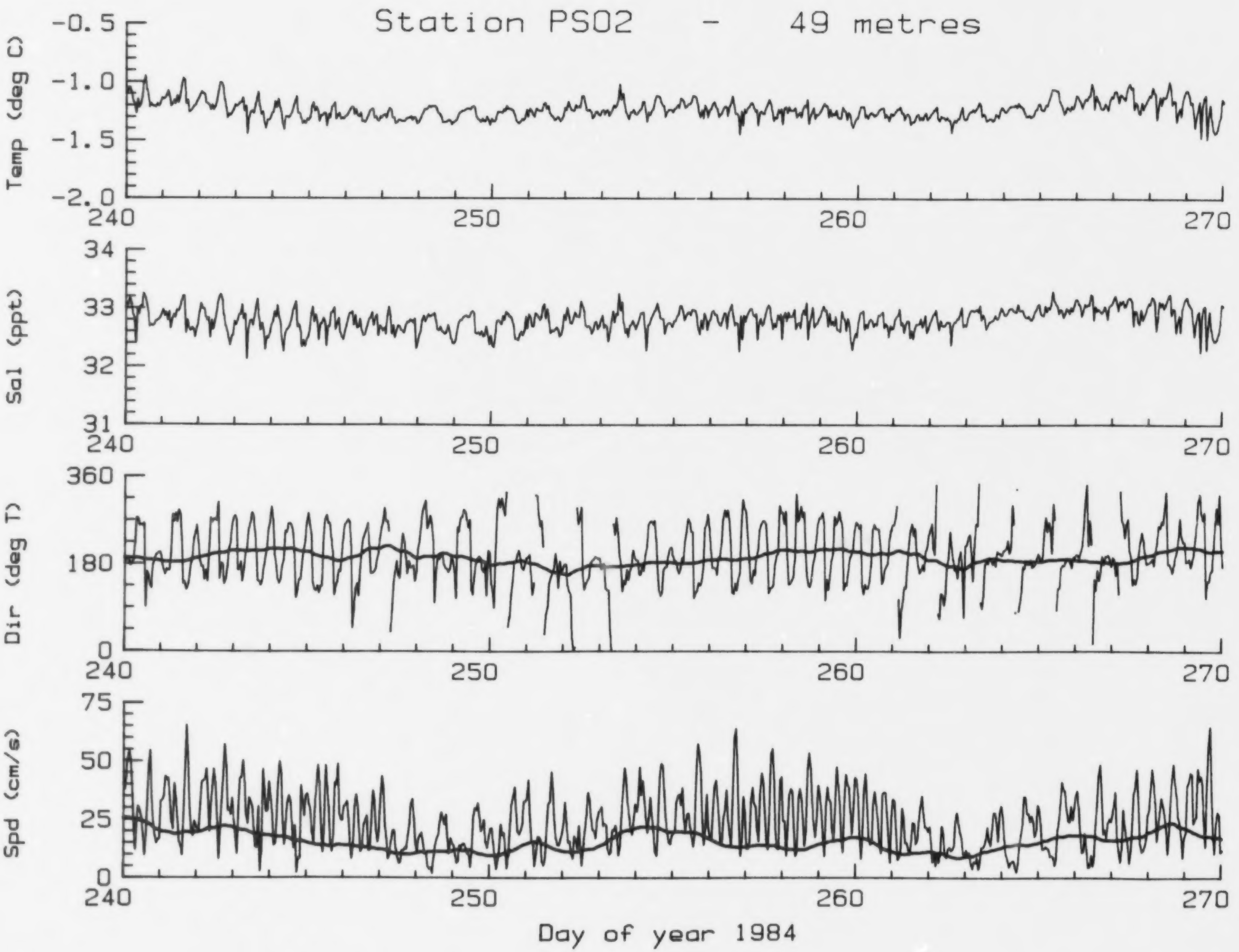
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
210
220
230
240
Day of year 1984


Station PS02 - 49 metres
Temp (deg C)
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-1.5
-2.0
Sal (ppt)
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Dir (deg T)
360
180
0
Spd (cm/s)
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25
0
240
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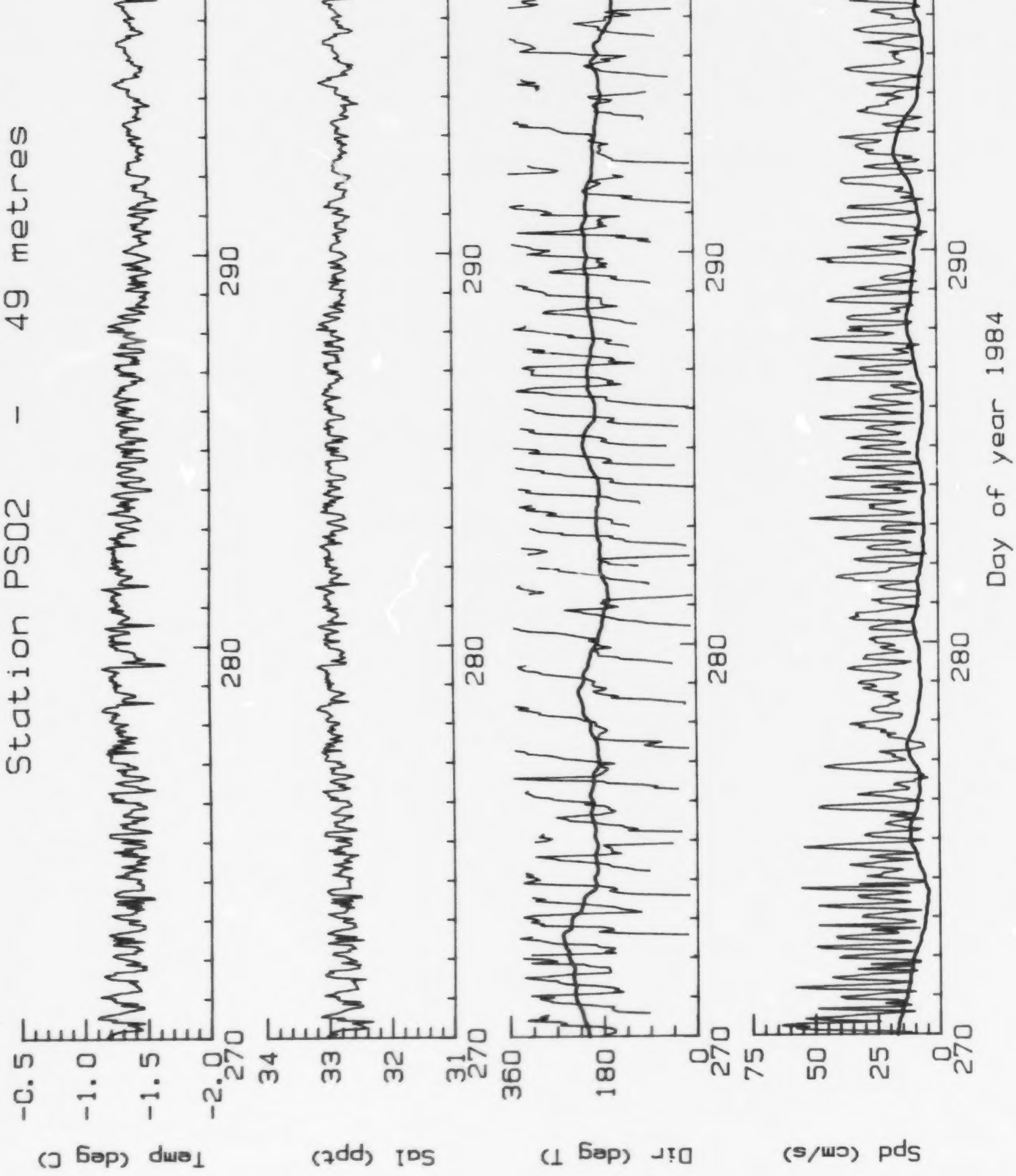
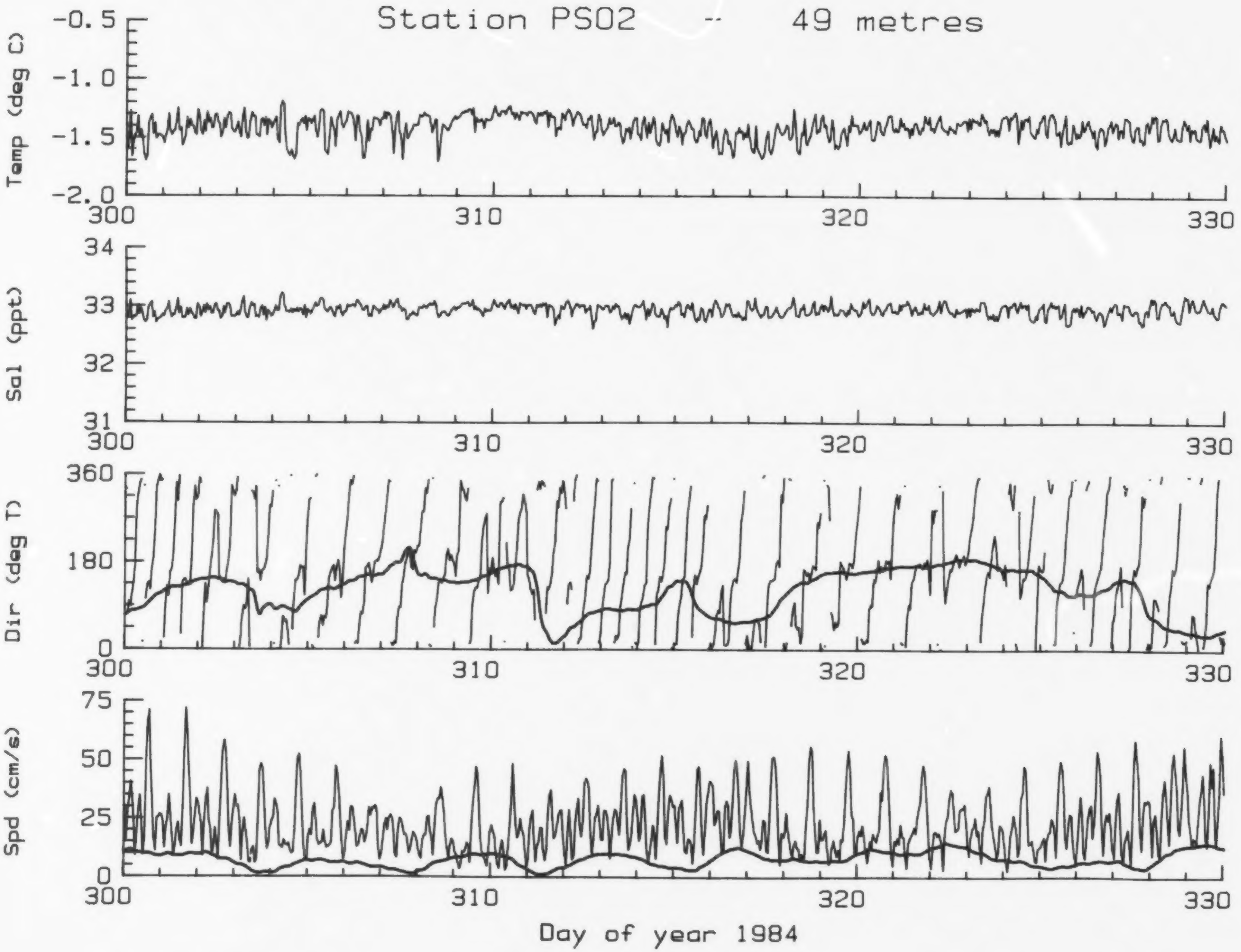
260
270
Day of year 1984



Station PS02 - 49 metres


Station PS02 -- 49 metres
Temp (deg C)
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-1.5
-2.0
Sal (ppt)
34
33
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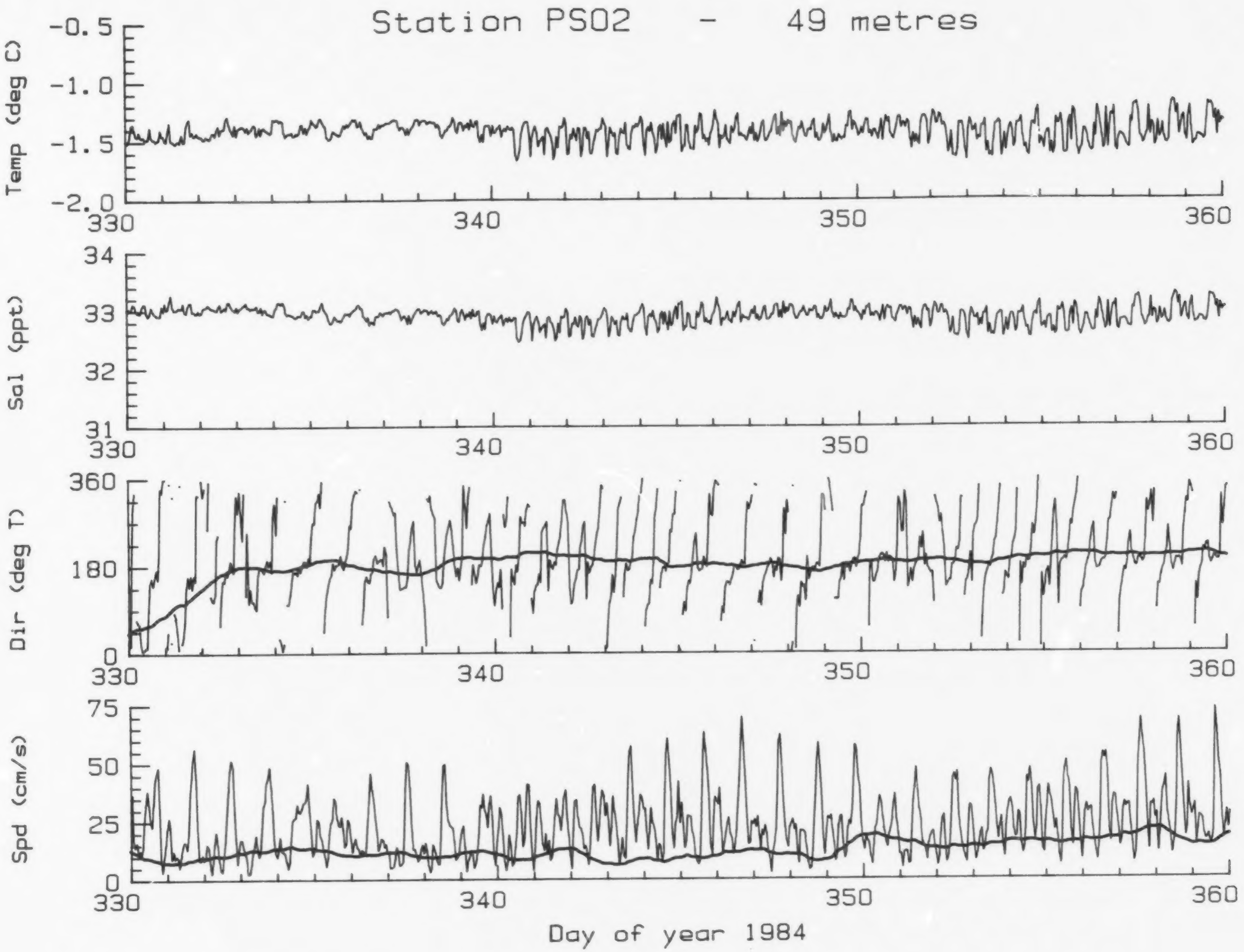
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
300
310
320
330
Day of year 1984


Station PS02 - 49 metres
Temp (deg C)
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-1.5
-2.0
Sal (ppt)
34
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Dir (deg T)
360
180
0
Spd (cm/s)
75
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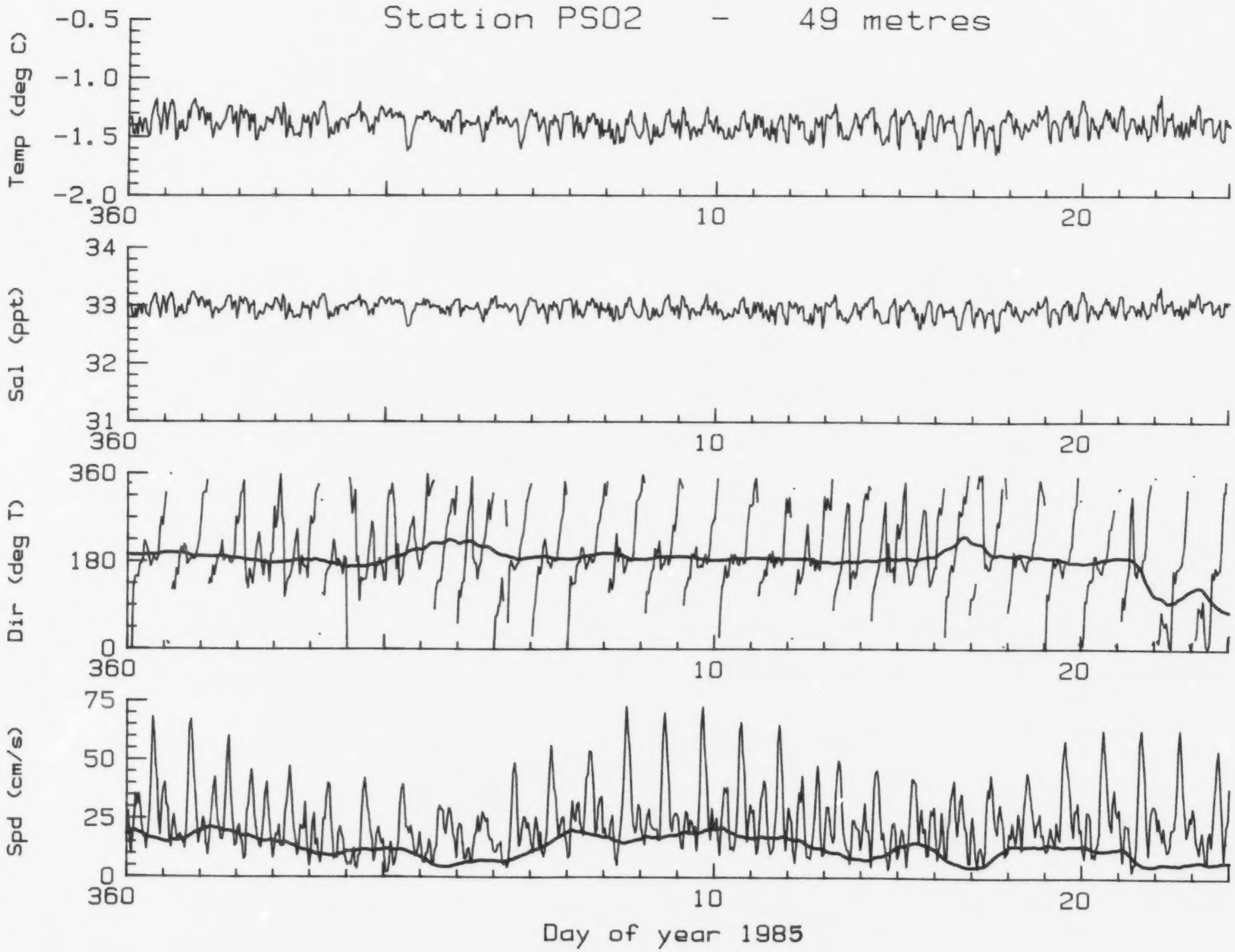
0
330
340
350
360
Day of year 1984


Station PS02 - 49 metres
Temp (deg C)
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-2.0
Sal (ppt)
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Dir (deg T)
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0
Spd (cm/s)
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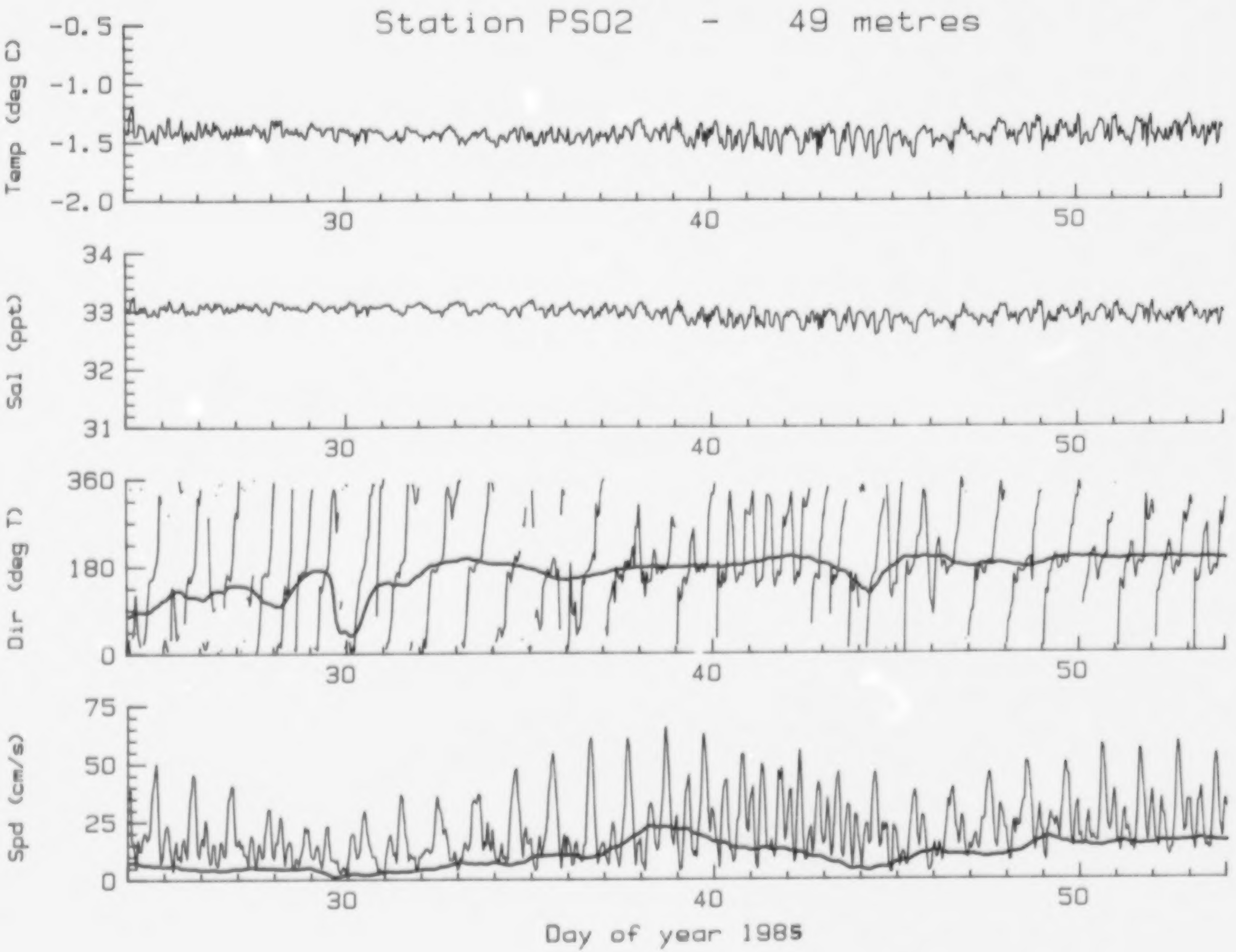
50
25
0
360
10
20
Day of year 1985


Station PS02 - 49 metres
Temp (deg C)
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-1.5
-2.0
Sal (ppt)
34
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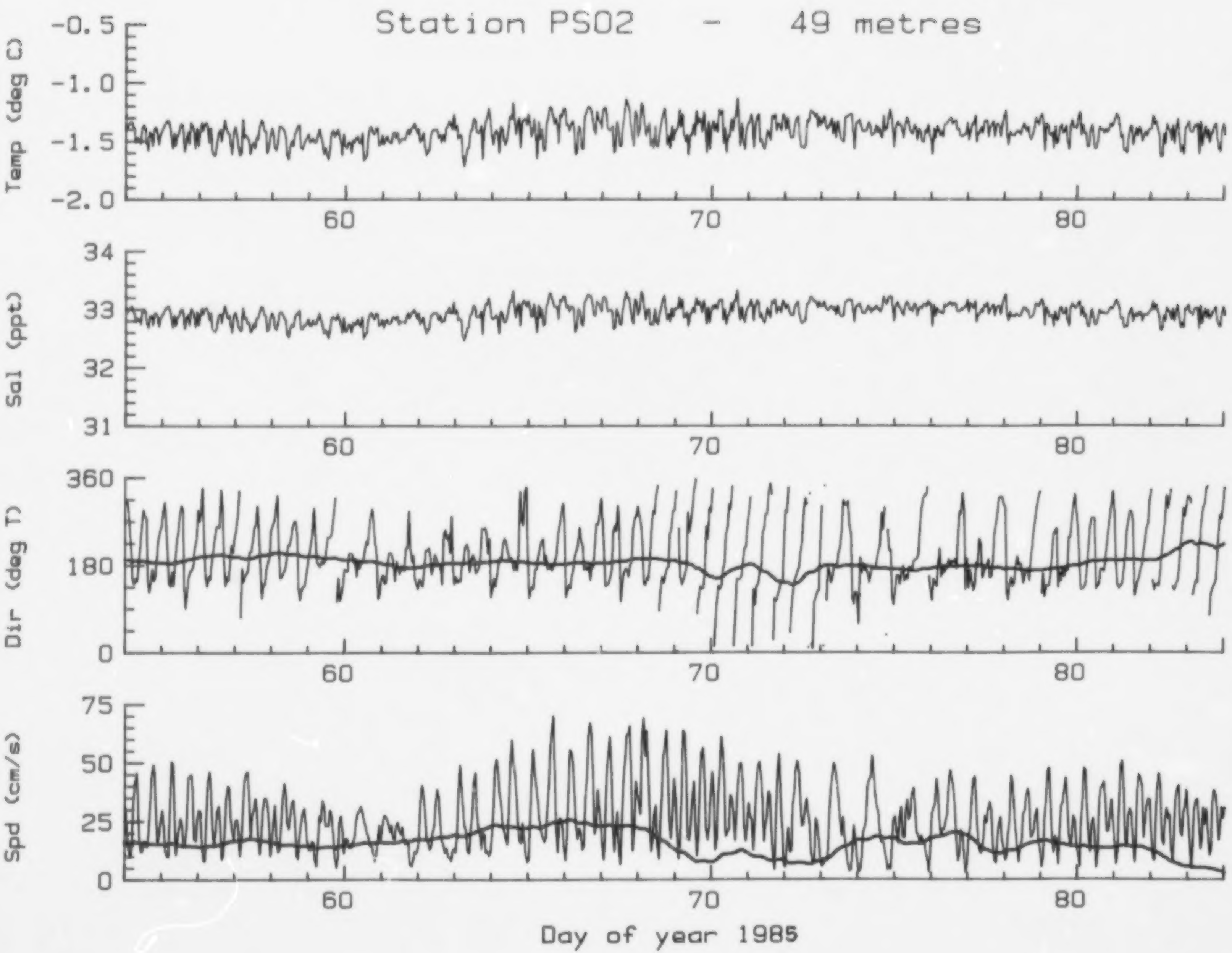
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
30
40
50
Day of year 1985


Station PS02 - 49 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
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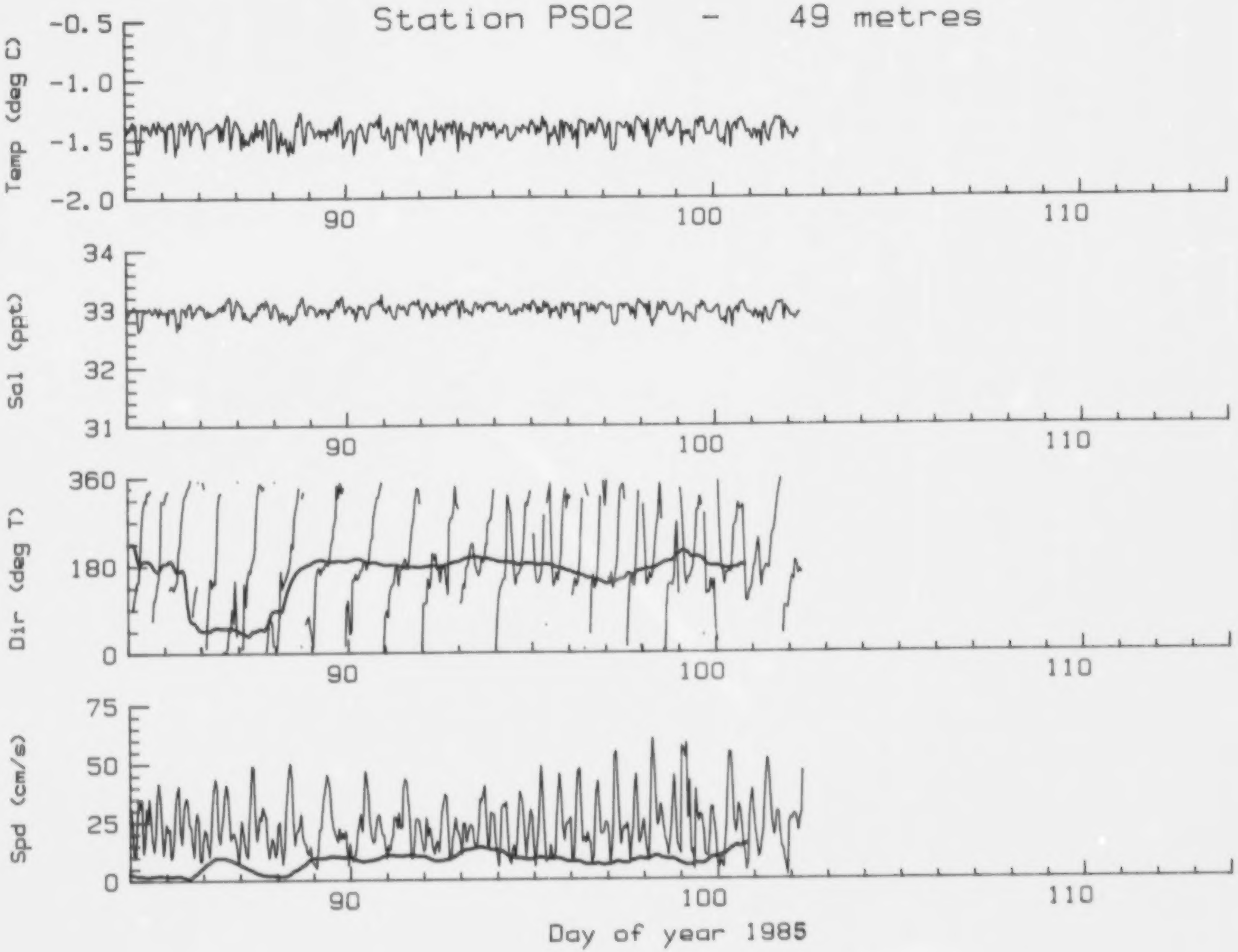
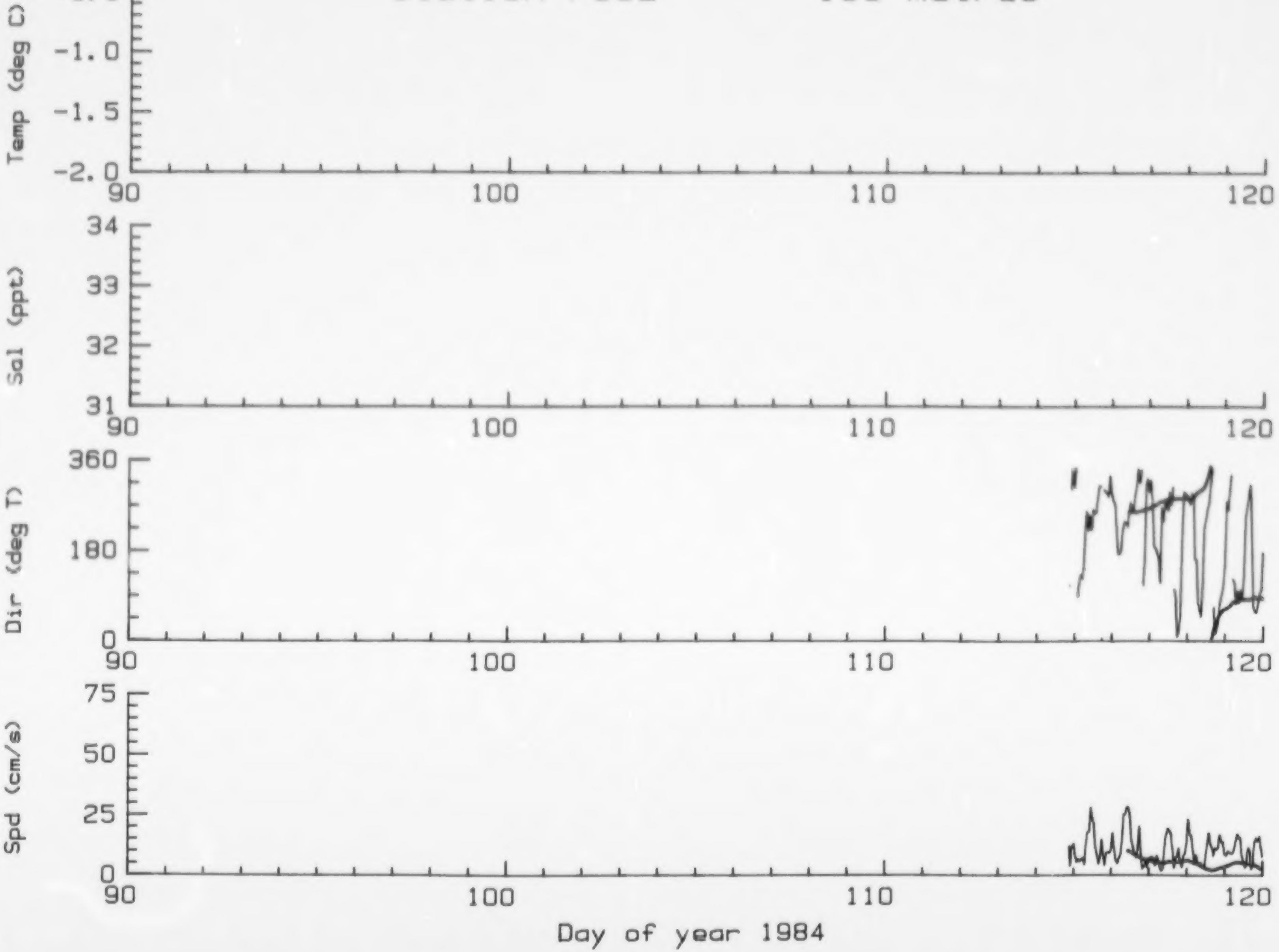
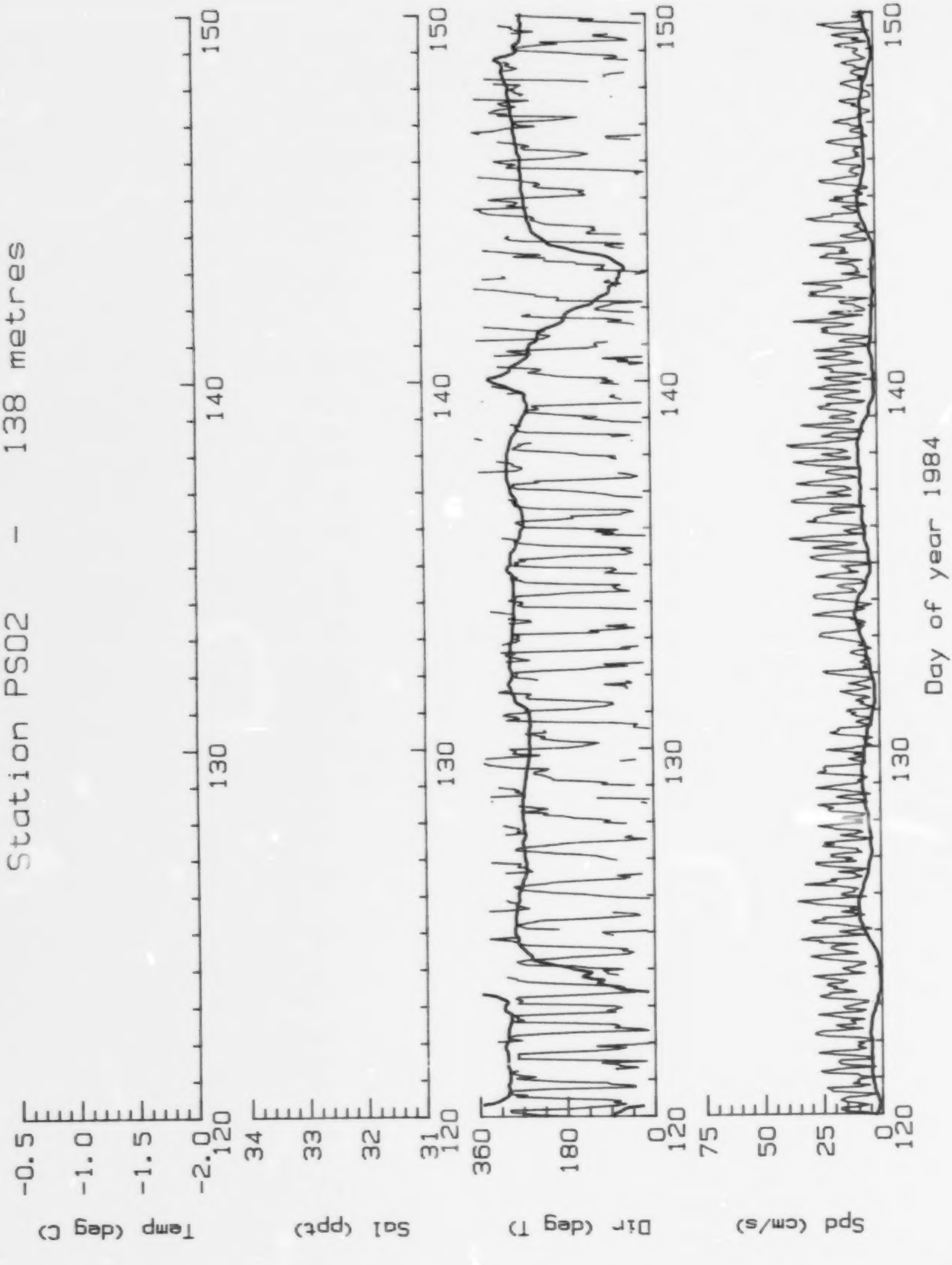
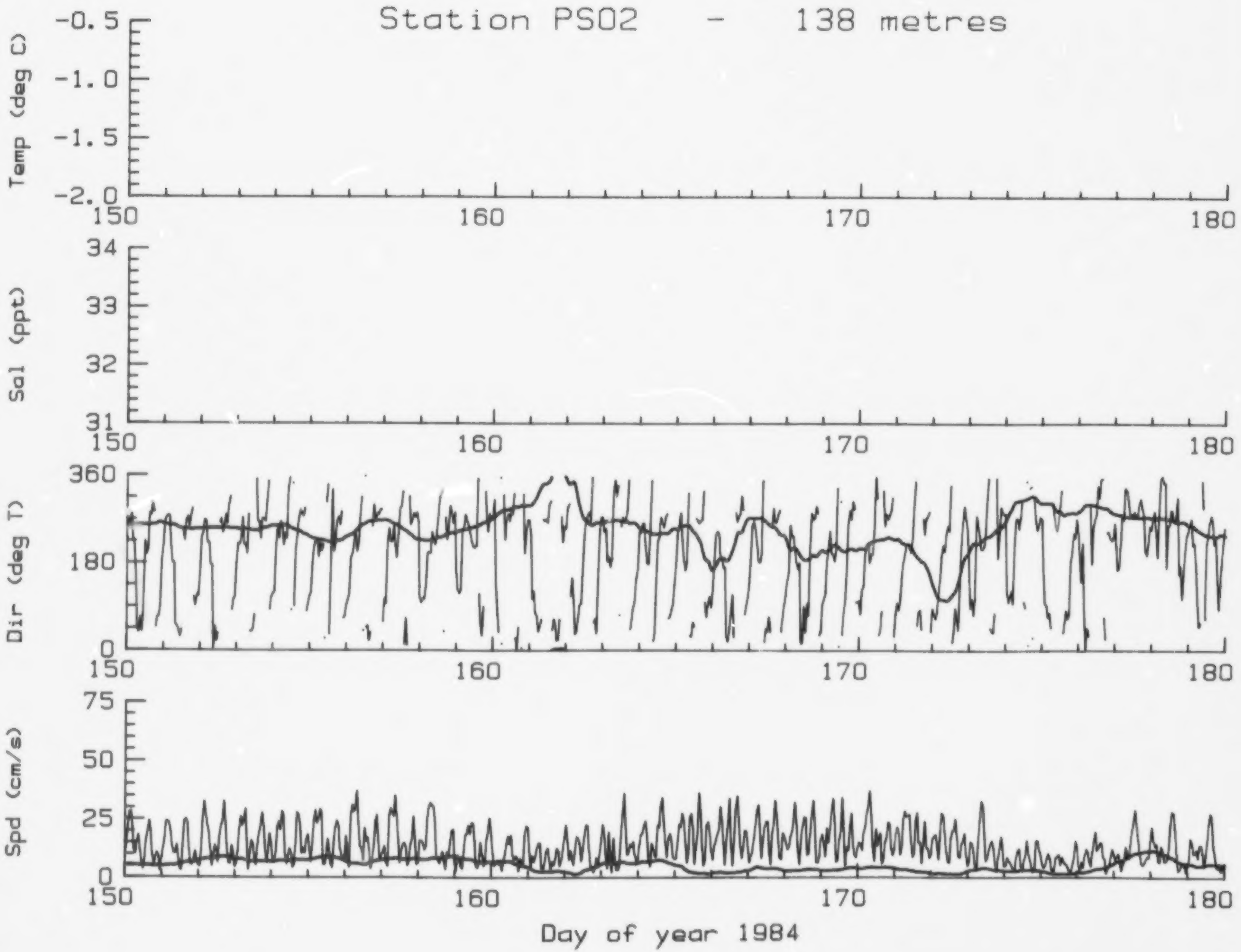
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
60
70
80
Day of year 1985



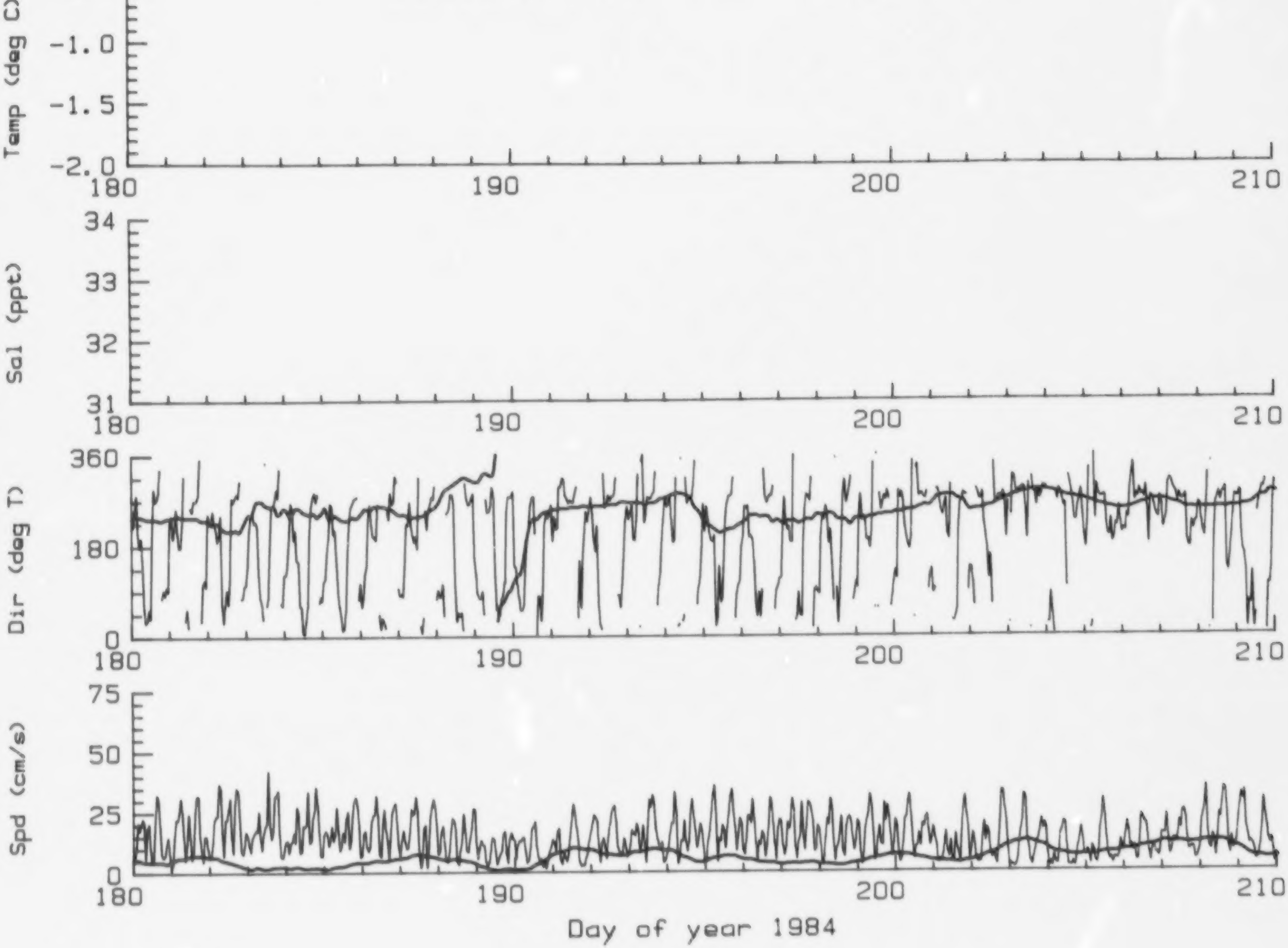
Station PS02 - 49 metres

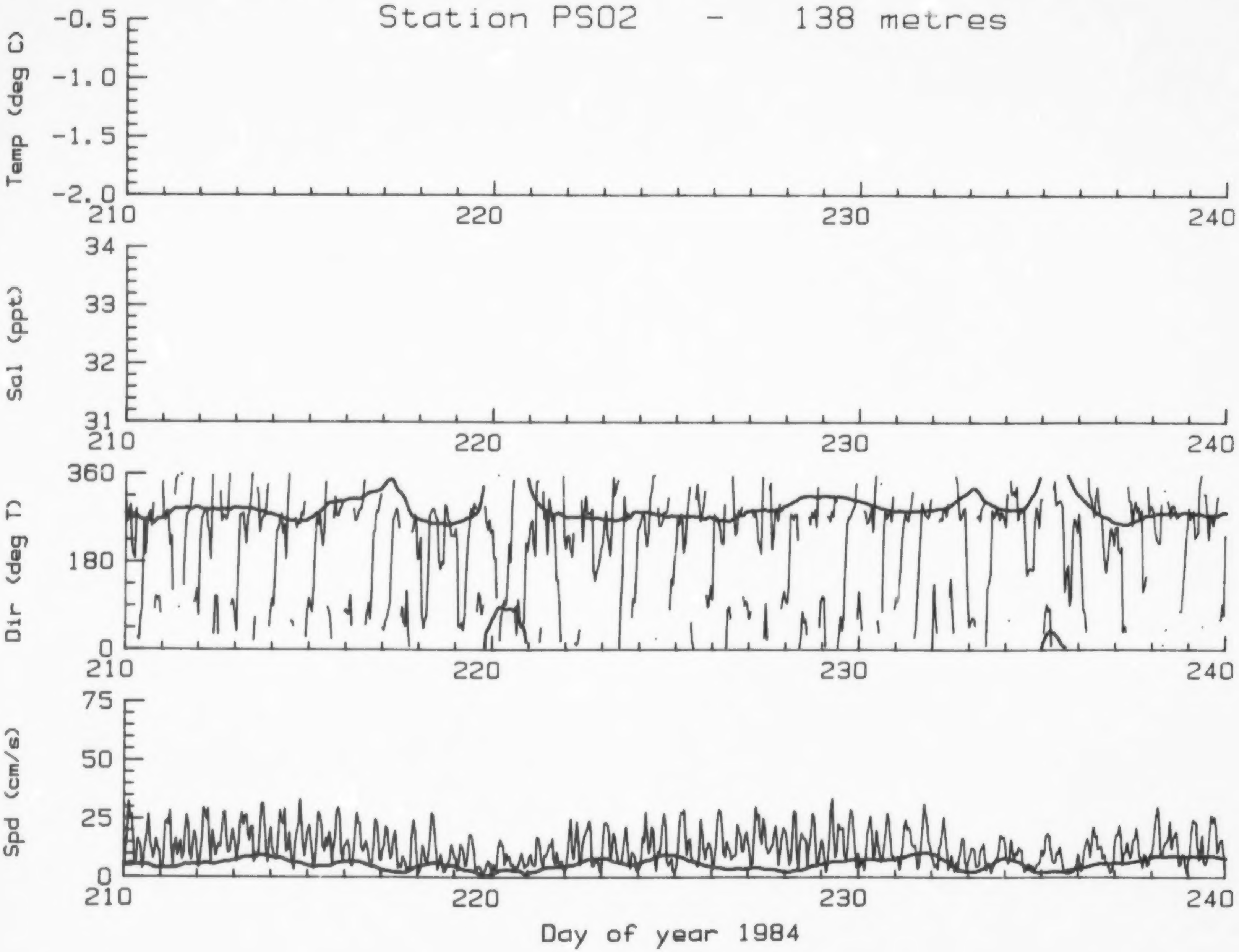

Station PS02 - 138 metres

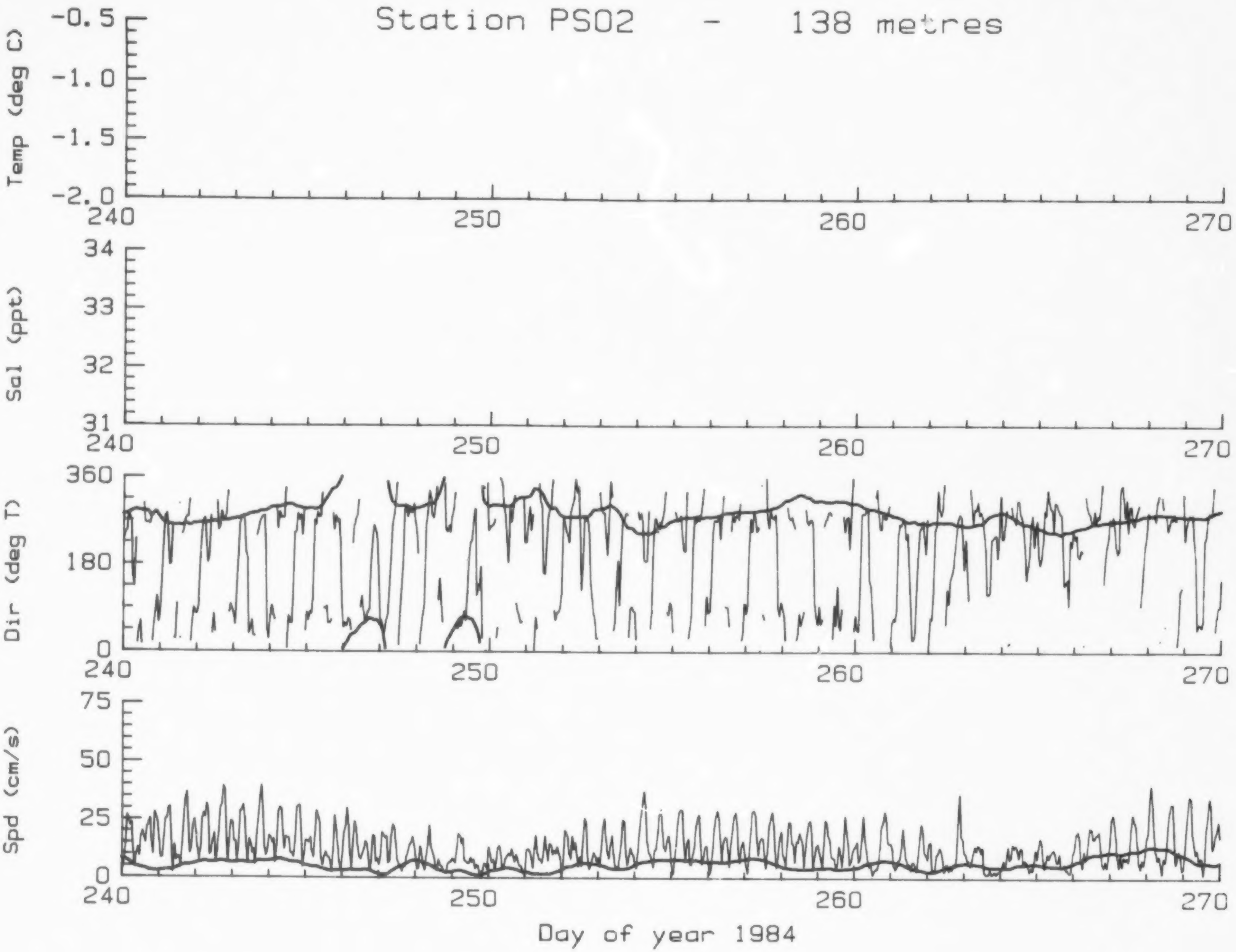

Station PS02 - 138 metres


Station PS02 - 138 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
150
160
170
180
Sal (ppt)
34
33
32
31
150
160
170
180
Dir (deg T)
360
180
0
150
160
170
180
Spd (cm/s)
75
50
25
0
150
160
170
180
Day of year 1984

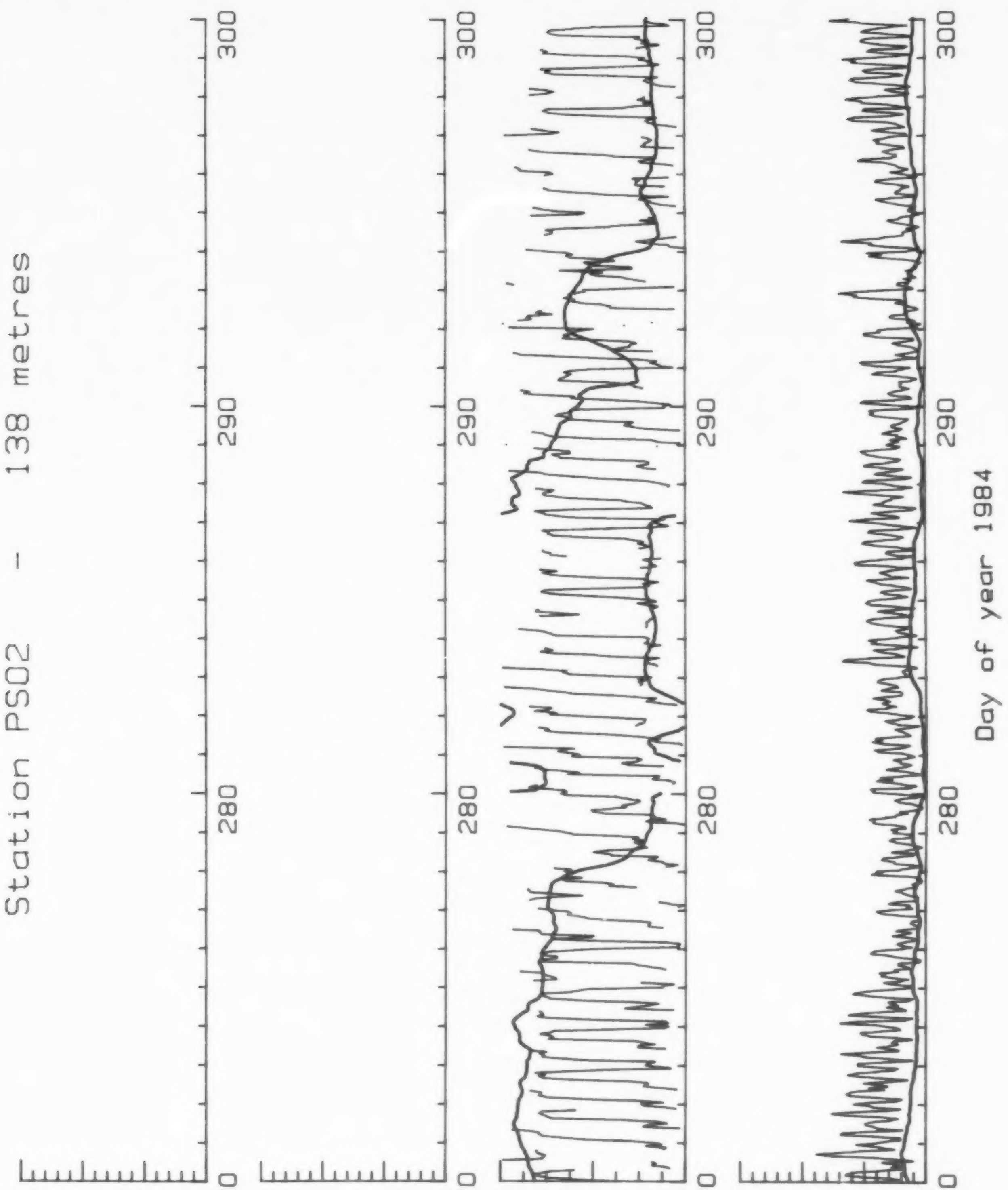
Station PS02 - 138 metres



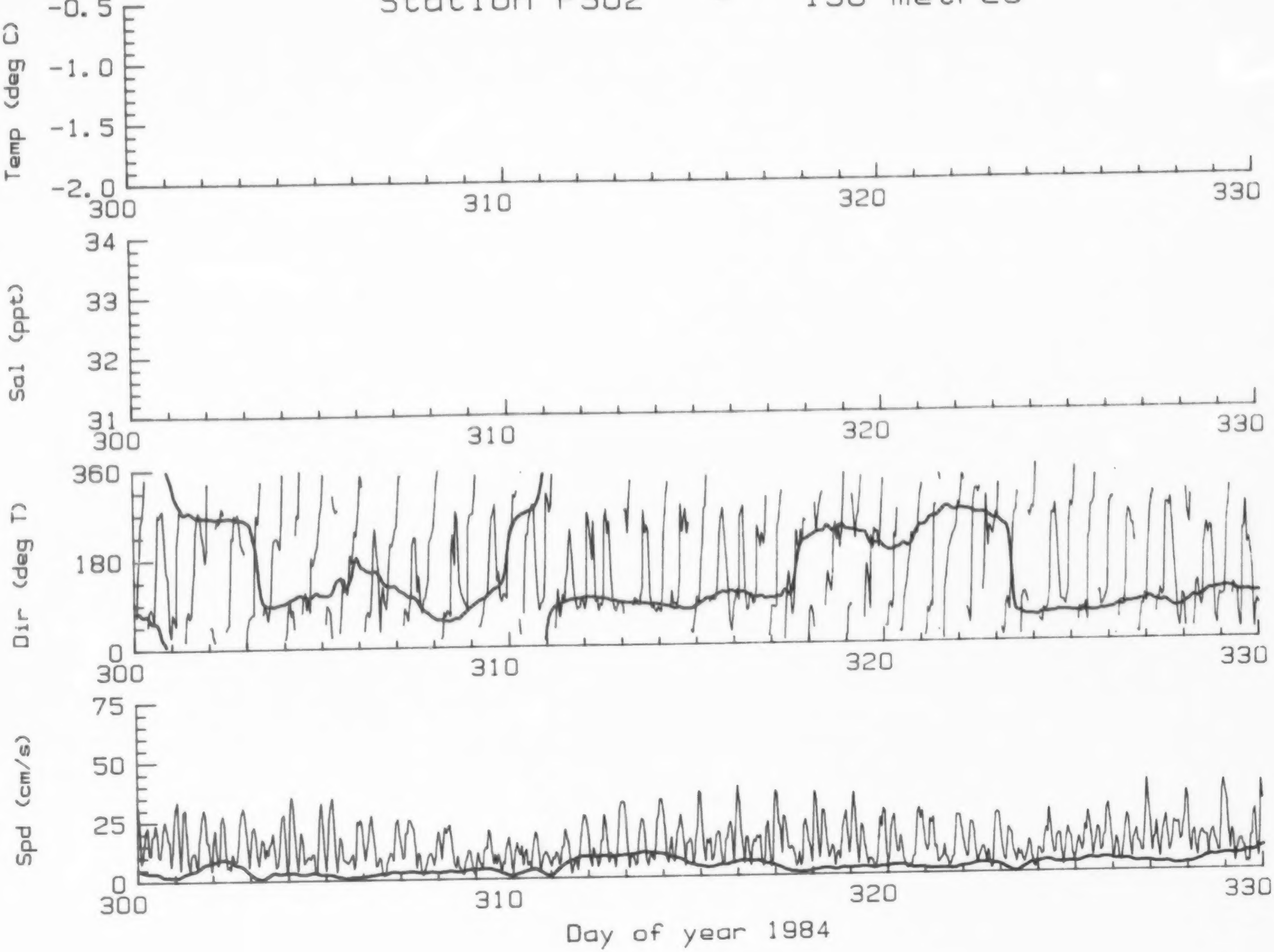

Station PS02 - 138 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
210
220
230
240
Day of year 1984

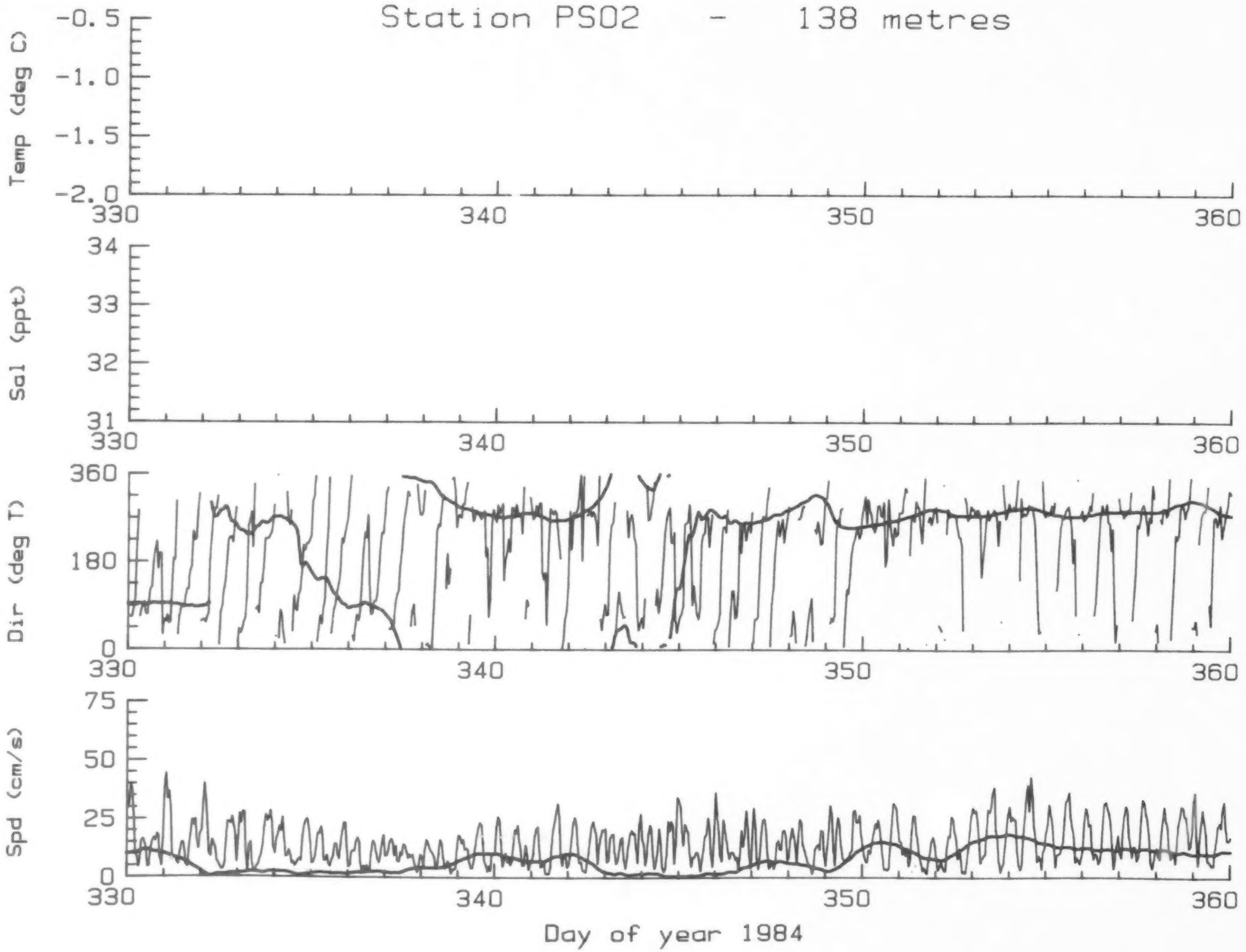


Station PS02 - 138 metres

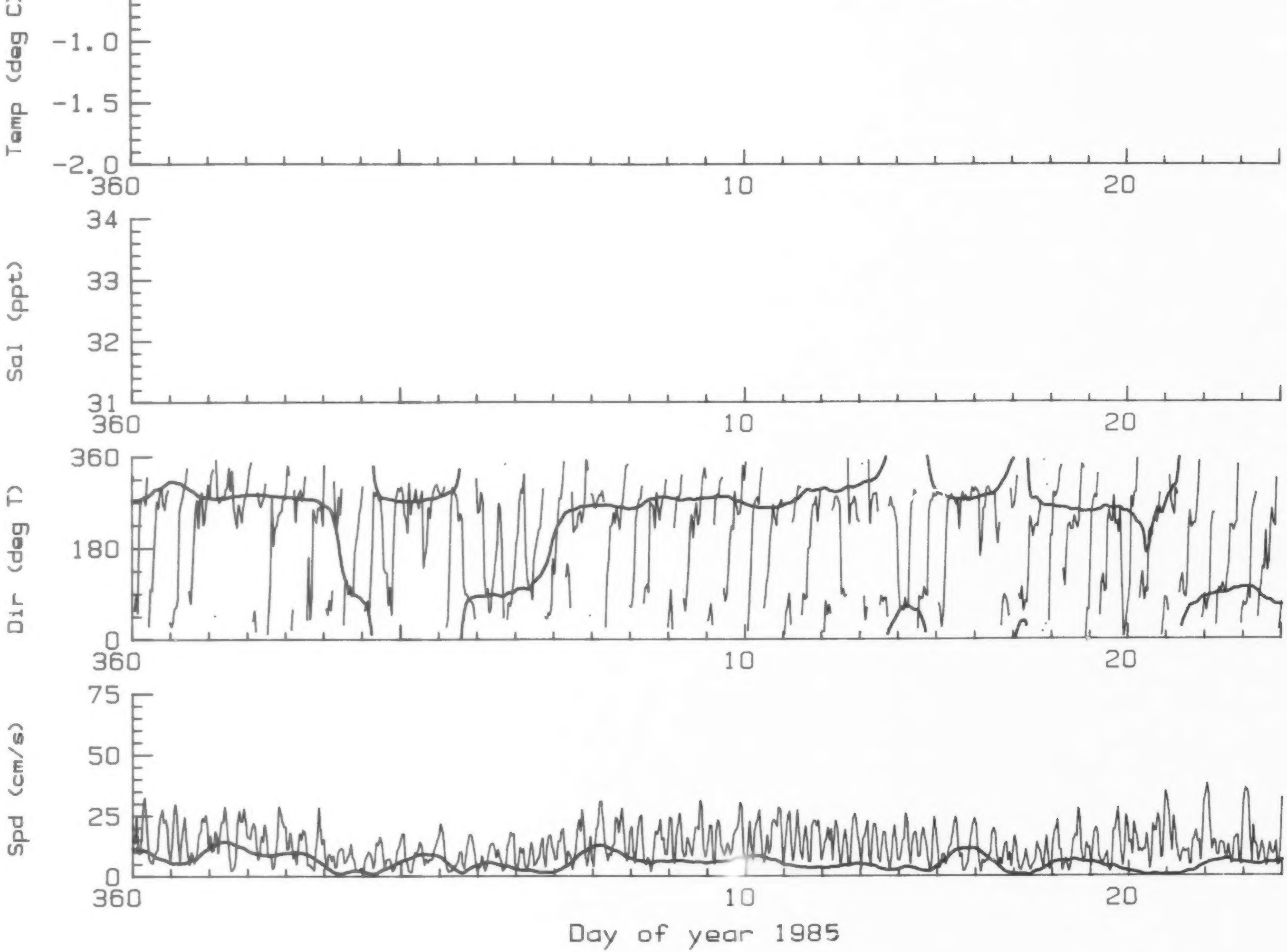

Station PS02 - 138 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
270
280
290
300
Day of year 1984

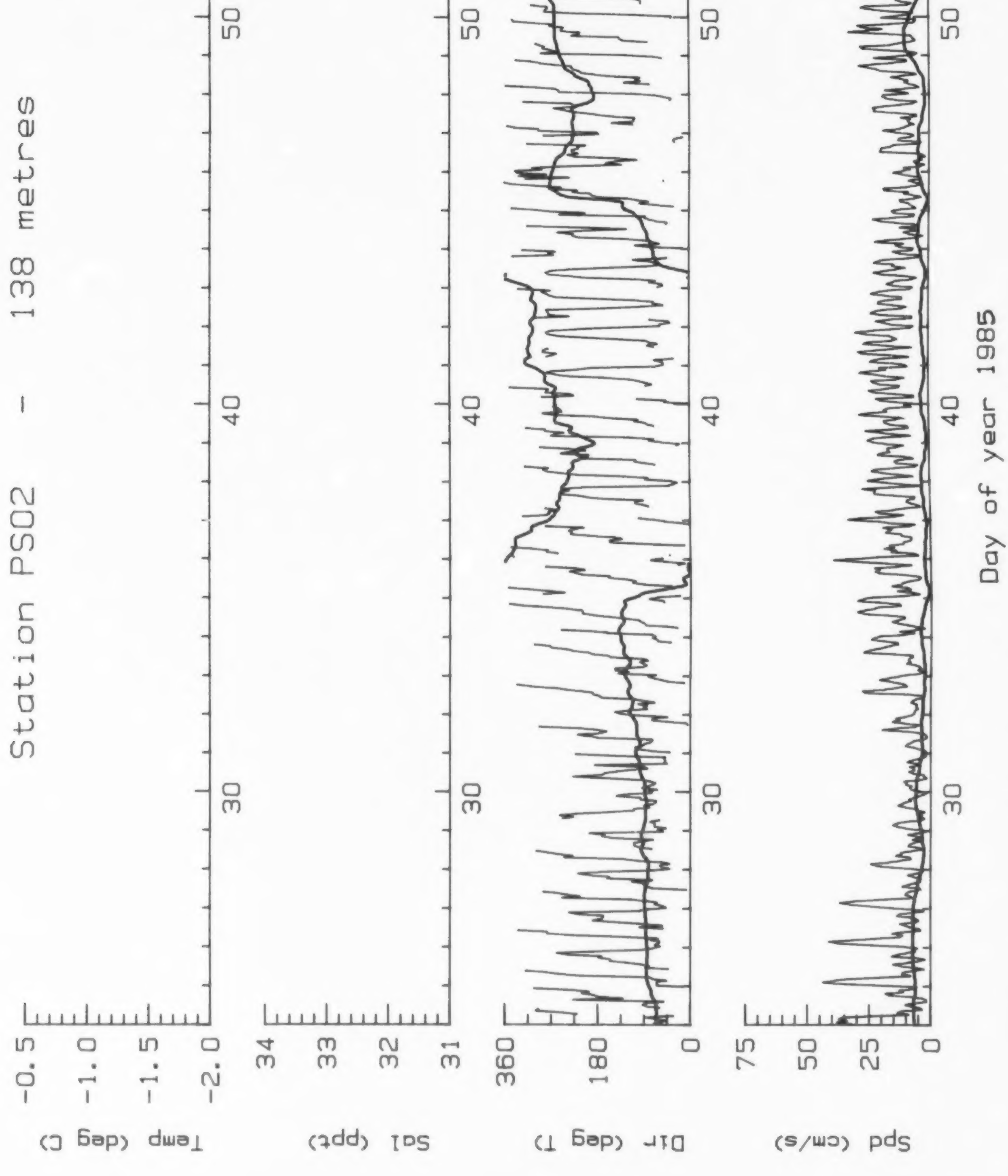
Station PS02 - 138 metres



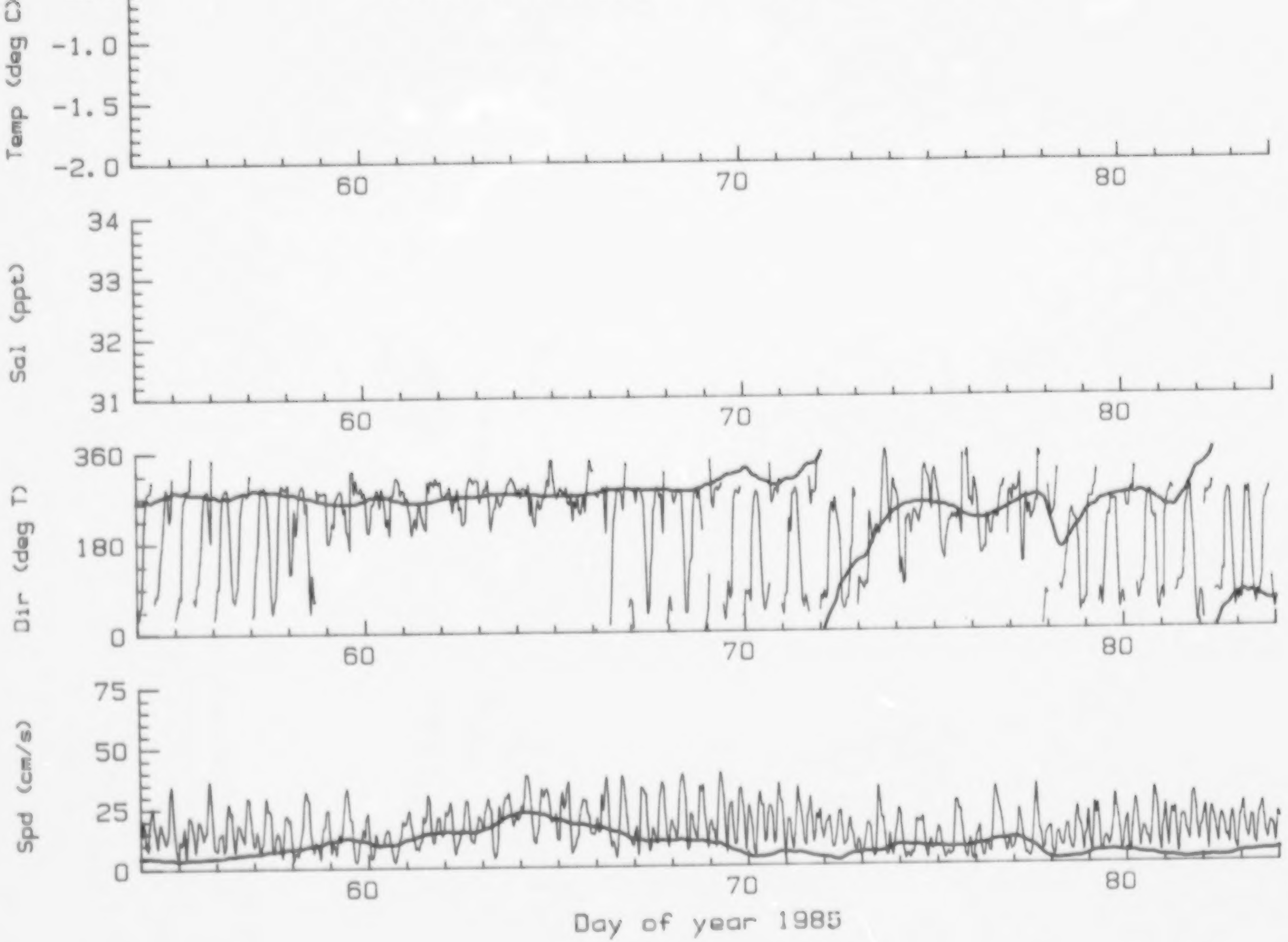

Station PS02 - 138 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
330
340
350
360
Day of year 1984

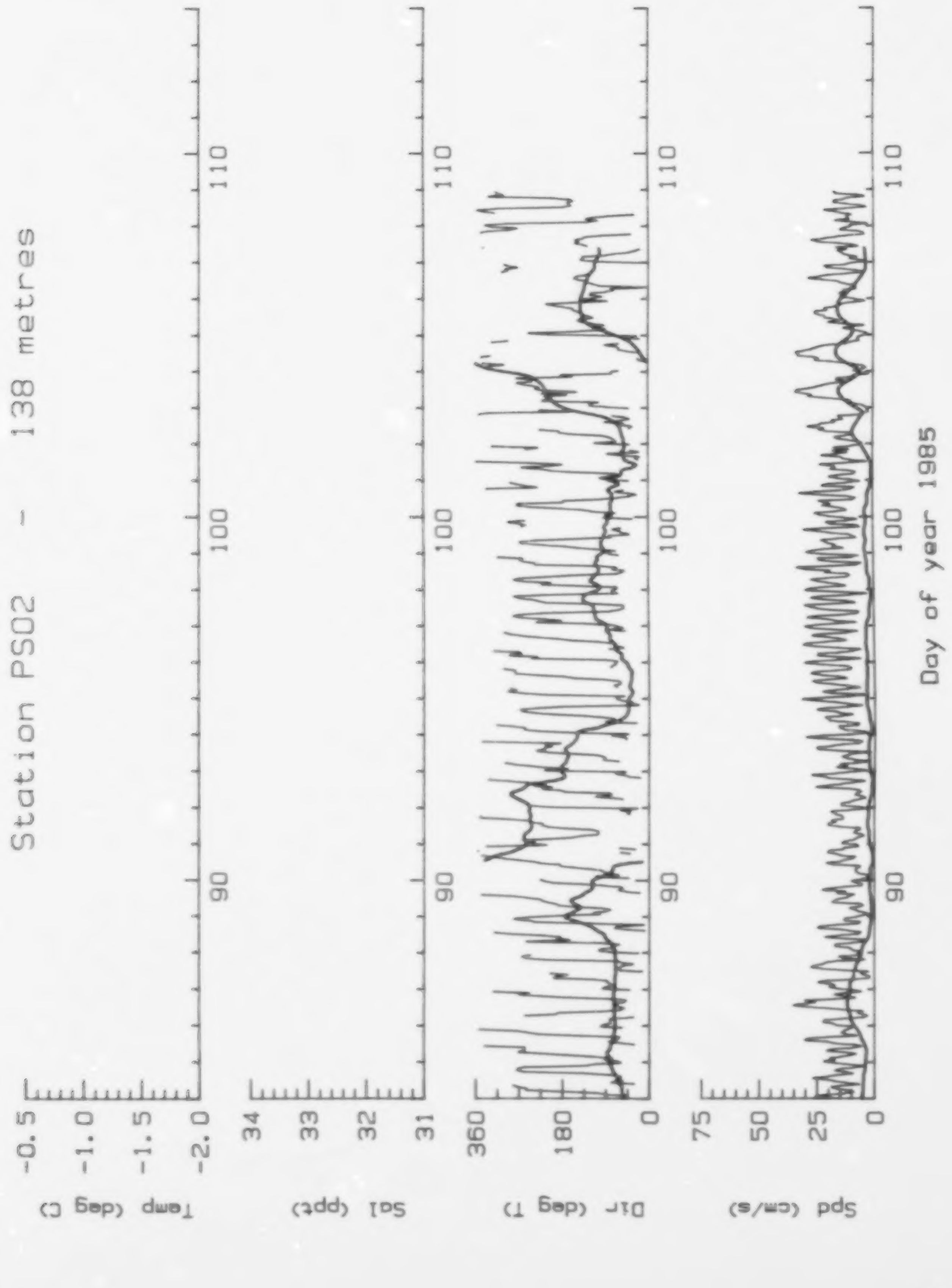
Station PS02 - 138 metres

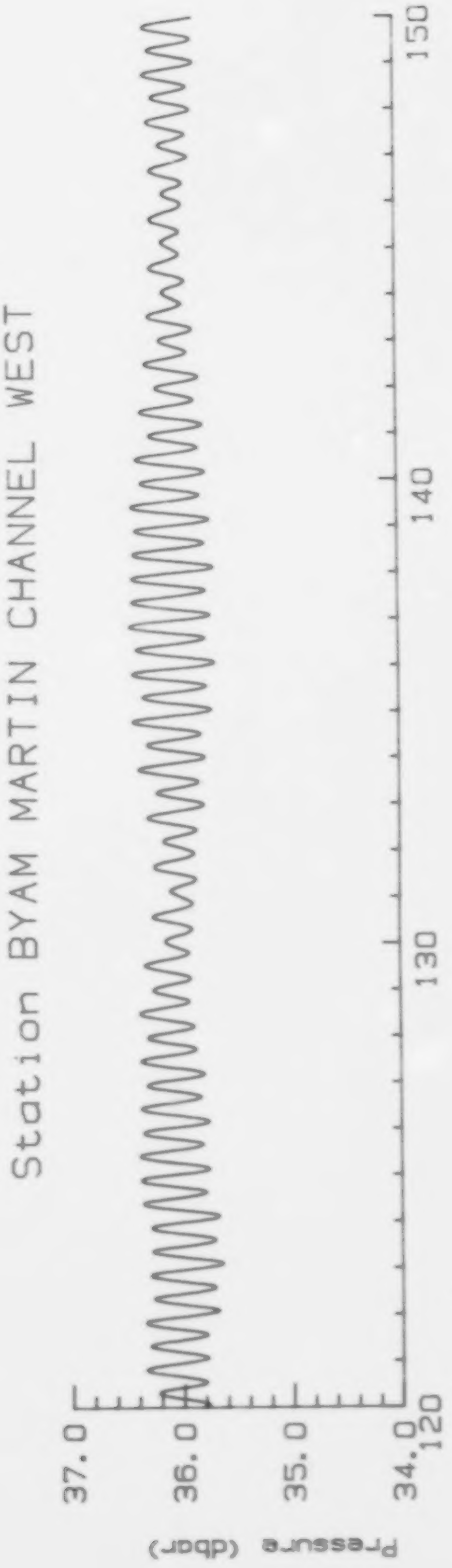


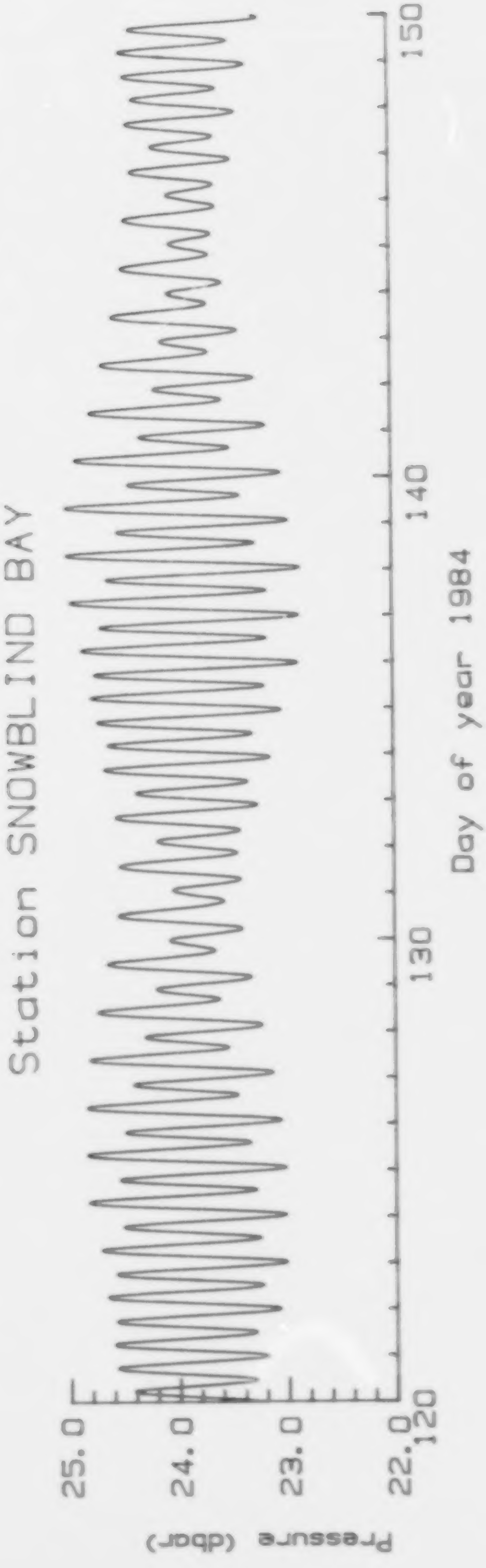

Station PS02 - 138 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
30
40
50
Day of year 1985

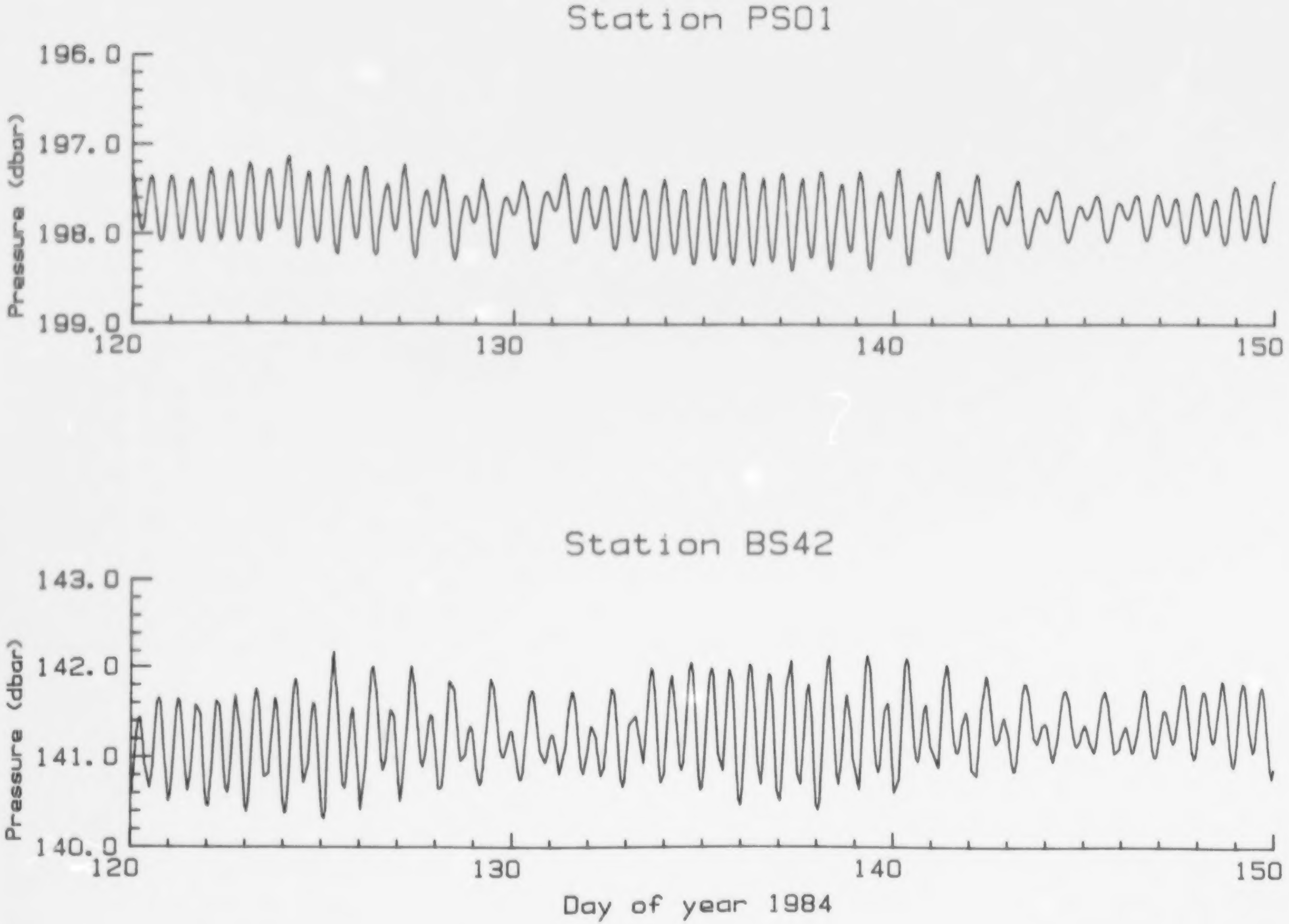
Station PS02 - 138 metres




Station PS02 - 138 metres
Temp (deg C)
-0.5
-1.0
-1.5
-2.0
Sal (ppt)
34
33
32
31
Dir (deg T)
360
180
0
Spd (cm/s)
75
50
25
0
90
100
110
Day of year 1985


Station BYAM MARTIN CHANNEL WEST
Pressure (dbar)
37.0
36.0
35.0
34.0
120
130
140
150


Station SNOWBLIND BAY
Pressure (dbar)
25.0
24.0
23.0
22.0
120
130
140
150
Day of year 1984


Station PS01
196.0
197.0
198.0
199.0
Pressure (dbar)
120
130
140
150
Station BS42
143.0
142.0
141.0
140.0
Pressure (dbar)
120
130
140
150
Day of year 1984